NUCLEAR WASTE MANAGEMENT ORGANIZATION
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NWMO BACKGROUND PAPERS
7. INSTITUTIONS AND GOVERNANCE

7-6 A COMPARATIVE OVERVIEW OF APPROACHES TO MANAGEMENT OF SPENT NUCLEAR FUEL AND HIGH LEVEL WASTES IN DIFFERENT COUNTRIES

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NWMO Background Papers

NWMO has commissioned a series of background papers which present concepts and contextual information about the state of our knowledge on important topics related to the management of radioactive waste. The intent of these background papers is to provide input to defining possible approaches for the long-term management of used nuclear fuel and to contribute to an informed dialogue with the public and other stakeholders. The papers currently available are posted on NWMO's web site. Additional papers may be commissioned.

The topics of the background papers can be classified under the following broad headings:

1. **Guiding Concepts –** describe key concepts which can help guide an informed dialogue with the public and other stakeholders on the topic of radioactive waste management. They include perspectives on risk, security, the precautionary approach, adaptive management, traditional knowledge and sustainable development.
2. **Social and Ethical Dimensions** - provide perspectives on the social and ethical dimensions of radioactive waste management. They include background papers prepared for roundtable discussions.
3. **Health and Safety –** provide information on the status of relevant research, technologies, standards and procedures to reduce radiation and security risk associated with radioactive waste management.
4. **Science and Environment –** provide information on the current status of relevant research on ecosystem processes and environmental management issues. They include descriptions of the current efforts, as well as the status of research into our understanding of the biosphere and geosphere.
5. **Economic Factors** - provide insight into the economic factors and financial requirements for the long-term management of used nuclear fuel.
6. **Technical Methods** - provide general descriptions of the three methods for the long-term management of used nuclear fuel as defined in the NFWA, as well as other possible methods and related system requirements.
7. **Institutions and Governance** - outline the current relevant legal, administrative and institutional requirements that may be applicable to the long-term management of spent nuclear fuel in Canada, including legislation, regulations, guidelines, protocols, directives, policies and procedures of various jurisdictions.

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Contents

1 INTRODUCTION

1.1 Why Look at What Others Are Doing?

Radioactive waste management is a highly technological, industrial activity that is carried out in numerous countries throughout the world, because they use nuclear power and/or some other applications of nuclear technology in medicine, industry or research. In the field of waste management, the sharing of knowledge and the level of interactions between different countries have both always been more intensive than in most other technical areas. This is not only because many aspects present novel technical challenges, but also because of the widespread recognition of the importance of arriving at solutions that are environmentally responsible and also socially acceptable.

An important factor encouraging open exchange of information is that there have been relatively few commercial interests behind the development of safe management and disposal routes. The largest civilian producers of radioactive wastes are nuclear power producers. For such organisations, the primary commercial function is producing and selling electricity. Solving the challenge of safe waste management is viewed as a necessary prerequisite for pursuing these activities. It has long been acknowledged as being of advantage to all, if suitable technologies can be developed and implemented; accordingly there has been strong support for open exchanges of know-how.

In addition, there has been a steadily increasing recognition of the fact that public transparency must be a key objective of waste management organisations. This growing awareness, resulting in part from some bitter setbacks and from strong societal pressures, has caused the nuclear industry, including waste managers, to abandon its early traditions of secrecy and closed decision processes. The growing need for transparency is reflected in the voluntary publication of extensive data in publicly available reports and on dedicated web sites. It has also led to binding requirements being set on waste management organisations by national and international regulatory bodies, in order to ensure open access to data. The most important recent example of this is the IAEA Joint Convention on Spent Fuel and Radioactive Wastes (IAEA 1997), which obliges all signatory states to submit regular detailed overviews of their national programs. The first set of such overviews, submitted to the IAEA in 2003 (IAEA 2003), forms a key part of the input documentation to the present report.

All of this substantial volume of information is of particular value to countries in which radioactive waste management programs are being initiated or are being re-structured. Canada is an example of the latter case. The Nuclear Waste Management Organisation (NWMO), as input for its spent nuclear fuel management strategy, has commissioned a series of documents, including the present international overview. The prime objective of this overview is to provide NWMO and the Canadian public with a reference framework against which to assess proposed national options for spent fuel management. For this reason, Canada itself is not treated in the same way as other countries. There is no country specific appendix for Canada since the NWMO Web site contains much more extensive national data. In isolated cases, however, (e.g. when discussing costs) Canadian data are included for easy comparison.

1.2 Which are the Most Relevant Countries to Compare with Canada?

There are 32 countries in the world that use nuclear energy, with a total of over 400 operating nuclear power plants. In addition, many more have research reactors (of which there are around 550 in the world) and a very large number use other nuclear technologies, in particular, sealed radiation sources. All such countries need structured programs for ensuring that the resulting unavoidable radioactive wastes are managed safely. The extent of nuclear activities, the resources available for waste management, and the maturity of actual management programs all vary widely. The selection of countries in the present document is based on the following considerations:

- **Key OECD countries**. Exchange of nuclear information through the Nuclear Energy Agency (NEA) of the OECD is particularly intensive. The selected OECD countries for profiling are Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Korea, Mexico, the Netherlands, Slovakia, Spain, Sweden, Switzerland, United Kingdom and USA. All of these have nuclear power wastes, including spent fuel, for which long-term management solutions must be sought.

- **Countries with Canadian nuclear reactor technology**. Over the years, Canada has exported the pressurized heavy water reactor (PHWR) technology developed in the country and used in all of Canada's CANDU reactors, to a number of other nations, namely Argentina, China, India, Pakistan, Romania and South Korea. Since the PHWR technology uses natural uranium and produces spent nuclear fuel with characteristics very different from that of other reactor types, it is valuable for Canada to compare the management strategies in PHWR user countries

- **Countries to which Canada has exported uranium**. Canada is the world's largest exporter of uranium and has shipped ore to many countries including Belgium, France, Finland, Germany, Italy, Japan, the Netherlands, South Korea, Spain, Sweden, Turkey, United Kingdom and USA, sometimes via another country (such as France, USA, or Russia) that has provided enrichment services. It could become increasingly of interest for Canada to interact with users of Canadian uranium, especially given the growing importance of the principle of Extended Producer Responsibility, EPR, (Dutta 2002). This principle, based on sustainability considerations, has been discussed to date mainly in the packaging industry. It could – if applied throughout the mining and minerals industries - lead to resource-rich countries considering return of wastes or else leasing rather than selling their raw materials.

1.3 Which are the Key Issues for Inter-Comparison?

There are very many parallels in how waste management is approached in various countries around the world, and there are also important differences. Some of the key challenges being addressed are of a very technical character; the prime example is perhaps development of the scientific methodologies needed to assess how geological repositories will behave far into the future. Some of the issues are more basic. How is the waste management program organised, operated and financed? What are the strategies for long-term management and the corresponding development programs and timescales? In an overview comparison of national programs, it is necessary to make a choice of topics for discussion and also of the depth of these discussions.

In the present report, the intention is to present those items that may be of most direct interest and value to an interested member of the Canadian public who is seeking a reference framework in which to judge the range of proposals that are being considered for defining the future strategy in Canada. With this goal in mind, the following questions have been addressed for the diversity of countries identified in Section 1.2:

- *How much radioactive waste arises and what are its key characteristics?* This will depend to a large extent on the importance of nuclear power in the country in question. But even countries with no use of nuclear energy will require programs to look after radioactive wastes arising from other applications of nuclear technology. In this overview, attention is focussed upon spent nuclear fuel (SNF) and high-level waste (HLW) from nuclear power production. Accordingly, for each country considered here, the present and anticipated future nuclear power program is noted together with the resulting quantities of those wastes.

- *What is the legal and regulatory framework that has been established in the country?* A transparent organisational framework is needed for ensuring that responsibilities are clearly allocated for implementation of waste management processes and for independent oversight of the implementer by a regulator.

- *What strategy has been chosen for waste management?* A national policy and a specific strategy for carrying out this policy must eventually be agreed in each country. Today some have already decided, some are considering different options, some are re-considering past decisions, and some are postponing any final decision. The most debated issue here concerns long-term waste management. Many countries, including Canada, started down a path leading towards geological disposal of radioactive wastes. Canada, together with a few others such as the UK and France, is presently looking at all potential management options. Even if a country does choose geological disposal, the question remains, whether it should be adopted now or be postponed for some defined time in favour of other strategies, such as continued storage?

- *How and where can waste management facilities be sited in a technically and societally acceptable manner?* Nuclear fuel cycle installations of any type (for power production, waste storage or disposal) are difficult to site. Finding a suitable location for a centralised storage facility or a radioactive waste repository is the most controversial of all topics in the radioactive waste context. The geological constraints on siting a repository are more severe than for other facilities and the timescales involved are much longer. Accordingly, the technical and the societal challenges are very high. This is due in part to the high standards that the nuclear industry has imposed on itself. The diversity of approaches that have been, or are being, used to meet those challenges is correspondingly wide.

- *How much will it all cost and where will the financing come from?* In an increasingly competitive energy market, this is a key question for nuclear power producers, who normally must provide the bulk of the funding. It is also a critical issue in waste management for the governments of countries with small or non-existent nuclear power programs but with other technologies that produce radioactive wastes.

- *How is the public bound into the decision processes by which answers are produced to all of the preceding questions?* This is perhaps the most topical issue. It is also the issue that is most affected by differences in national cultures - but valuable insights can nevertheless be gained by comparison of national approaches.

- *How closely do countries developing waste management programs interact with other nations facing the same challenge?* Much of the technological basis of waste management is generic, independent of national boundaries. Thus, there is potentially much scope for cooperation. Some aspects, in particular those concerning local geological conditions or national societal attitudes are much more diverse. Under these differing conditions, how much can be gained from cooperation between countries?

This report is structured so as to enable the interested reader to see how the above list of questions has been addressed in different countries. Chapter 2 looks at each key issue in turn and comments upon important parallels and differences, giving specific examples when appropriate. This thematic overview is complemented by the extensive list of country-specific summaries in the Appendix. These summaries are structured in a uniform fashion so that each key issue is addressed in turn for the country in question.

The country specific material is augmented in Chapter 3 by a description of the important role of international organisations in the waste management field. Finally the report is rounded out by a compilation of useful overview documents and specific references. These should serve readers who wish to go in more depth into any of the points raised in the report.

2 OVERARCHING COMMENTS ON KEY ISSUES

2.1 Radioactive Wastes Arising World-Wide

2.1.1 Waste sources

Radioactive wastes arise from many of today's technologies. Some quantity of wastes arises in almost every industrialised or developing country. The sources, inventories and characteristics of the wastes vary markedly, however. In the country appendices to this document, the current and expected inventories of spent fuel and high-level radioactive wastes from a range of countries are detailed. Here, we give a very short overview of all types of radioactive wastes and discuss briefly the differences in categorisation of the wastes by different countries.

The main sources of radioactive wastes are from

- the nuclear power fuel cycle,
- application of nuclear techniques in medicine, industry and research,
- programs for weapons production or dismantling (in the nuclear weapons states).

All of the countries discussed in this overview have wastes from the first two sources. Weapon production wastes arise in the 8 countries acknowledged to have military nuclear programs (USA, Russia, UK, France, China, India, Pakistan, Israel). Although the "legacy wastes" arising from weapons production are a major component of the radioactive wastes in such countries, they are not discussed in this document. The category with which we are concerned in the present report is fuel cycle wastes. These include:

- uranium mine tailings,
- residues from uranium enrichment and fuel fabrication,
- wastes produced in the operation of nuclear power plants, including the spent fuel,
- wastes from decommissioning of nuclear facilities.

Within these fuel cycle wastes, attention is focussed upon the used or spent nuclear fuel (SNF) from the reactor core or on the high level radioactive residues (HLW) produced if the fuel is reprocessed. The safe management of these wastes is generally reckoned to provide the greatest challenge because they are extremely radioactive initially, and retain significant levels of radioactivity for very long periods. The Canadian waste management organisation, NWMO, has been established with the specific mission of developing a management approach for the long-term care of spent fuel. Although the focus is on SNF it is worth noting that other radioactive waste types can also provide important challenges because of their large volumes (e.g. tailings, decommissioning wastes) or their longevity (e.g. some medical wastes and spent sealed sources).

2.1.2 Waste categorisation

Originally, radioactive wastes were classified in the nuclear industry primarily depending upon the intensity of the radiation emitted. This reflected the fact that waste management was chiefly concerned with the treatment, packaging and handling of wastes - all of which are operational activities that can give radiation doses to workers. This led to the simple classification of wastes as low level (LLW), intermediate level (ILW) or high level (HLW).The important characteristics were the specific activities and concentrations of radionuclides, the type of radiation emitted, the level of shielding required and the amount of heat generated. High Level Waste is also described in the IAEA Glossary according to its origins as:

(a) The radioactive liquid containing most of the fission products and actinides originally present in spent fuel and forming the residue from the first stage solvent extraction cycle in reprocessing, and some of the associated waste streams.

(b) Solidified HLW from (a) above and spent nuclear fuel, if it is declared a waste. (Some countries refuse to declare SNF as waste, since they regard the fissionable material remaining in the fuel as a potential energy resource).

(c) Any other waste with an activity comparable to (a) or (b).

With growing recognition of the importance of safe long-term management, more attention was focussed on the half-lives of the radionuclides in the wastes, since this determines the necessary period for which they must be isolated from the human environment. This led, for example, the European Community (EC) to propose a scheme in which the low and intermediate wastes (LILW) are divided into 2 categories LILW-SL and LILW-LL (EC 1999). The former “short lived” is for wastes with primarily radionuclides with half lives of 30y or less, with a specified low limit for the content of long-lived alpha emitting radionuclides. LILW-LL wastes exceed this limit. The other key category is HLW and this is defined as wastes for which heat generation is a key characteristic; included in this category is spent nuclear fuel (SNF) – assuming that this spent fuel is to be disposed of rather than treated as a resource from which fissionable materials can be recovered.. The IAEA has defined a unified classification scheme that is intended to promote standardisation (IAEA 1994a).

Class	Description
Low-level (short-lived)/ decay waste	Low-level radioactive waste containing short-lived radionuclides only (e.g. with half-lives less than 100 days), that will decay to clearance levels within 3 years of being produced
Low- and intermediate-level short-lived waste (LILW-SL)	Waste that will not decay to clearance levels within 3 years, containing beta- and gamma-emitting radionuclides with half-lives less than 30 years and/or alpha-emitting radionuclides with an activity less than 400 Bq/g and a total activity of less than

Class	Description
	4000 Bq in each waste package
Low- and intermediate-level long-lived waste (LILW-LL)	Radioactive waste that contains radionuclides at concentrations above those for LILW-SL but with heat-generating capacity not exceeding 2 kW/m^3 of waste
High-level waste(HLW)	Radioactive waste that contains radionuclides at concentrations above those for LILW-SL and with heat-generating capacity above 2 kW/m^3 of waste

In this report, the term high-level waste (HLW) is used, when discussing disposal issues, to cover all materials with high levels of radiation, heat generation and long-lived radionuclides. The term spent fuel (SNF) is used on its own, when discussing inventories unloaded from reactors and stored at the reactor or at a centralised location.

At the conceptual planning stage, it is sufficient to consider spent nuclear fuel as a single waste category for which a suitable long-term management solution must be sought. As national programs mature and management approaches become more specific, a more detailed categorisation may be needed. Different fuel types arise from different reactor types (LWR, PHWR, GCR, FBR, research reactors); lesser quantities of other long-lived wastes (e.g. control rods, core internals) must be managed along with the spent fuel. These refinements have direct implications on the engineering of storage or disposal facilities and on their safety assessment. Countries that are closest to repository implementation (e.g. USA, Sweden Finland) therefore have waste categorisation schemes with much higher resolution. In practice, most countries begin to address this issue even in the early development phases, since the consequences on repository design and performance can be high. Specific examples are in the Swiss and Belgian programs. Although neither will implement a spent fuel repository for some decades, both engage in detailed waste categorisation and repository design work. In Switzerland, much effort has been devoted to studying the influence of high burn-up MOX fuel on repository plans; in Belgium specific studies have been performed on optimising the use of underground space by emplacing long-lived wastes around the HLW packages in disposal tunnels.

Today, the classification systems used in different countries are not uniform. Some countries directly categorise the wastes by allocating them to a specific waste repository type. This is the case, for example, in Belgium, France, Sweden and the USA. All of these countries have, or propose to have, near surface disposal for short-lived radioactive wastes and also facilities for deep disposal of long-lived wastes. Germany, which has no plans for near-surface disposal, lays special emphasis on the heat generation levels, with only those waste packages that do not increase the rock temperature by more than 3°C being allowed into the planned Konrad repository. Switzerland has proposed a site-specific allocation of wastes for disposal, with the acceptability of specific waste types into a proposed underground cavern repository being decided based on waste- and site-specific safety assessments. In the USA, where the WIPP facility in New Mexico is the only repository world-wide accepting wastes with high levels of long-lived transuranic nuclides, the categorisation is based on the concentration of such nuclides and upon the heat generation.

In the appendices to this report, it will be seen that a diversity of specific categorisation schemes are still in use. This is acceptable as long as an internally self-consistent system is in operation that ensures that all waste categories are handled safely throughout all stages of the waste management. In supra-national environments, such as the EU, still greater consistency is needed. Should international storage facilities or repositories be realised, the need for careful coordination of standards and of waste categorisation will increase yet further. Ultimately, every operational storage or disposal facility will have to have a specific set of waste acceptance criteria and a corresponding quality control system to ensure that only wastes meeting these criteria will be emplaced in the facility.

2.1.3 Spent nuclear fuel arising world wide

Up to the beginning of 2003, around 255,000 tonnes of spent fuel had been produced by over 400 power reactors world-wide and the continuing production rate is over 10,000 tonnes per year. With the new reactors under construction (mostly in Asia), it is estimated that by 2010 there will be about 340,000 tonnes and by 2020 about 457,000 tonnes of spent fuel. Table 2.1 gives an overview of the current situation for the countries discussed in this report and includes, for comparison, also the Canadian figures.

Table 2.1: Overview of the Spent Nuclear Fuel Production

Country	No. of Power Reactors 2003	Total MWe from nuclear 2003	Cumulative tonnes of SNF 2000[1]	Cumulative tonnes of SNF 2020[1,2]	Comments
Argentina	2	1,000	2,480	4,320	The Argentinean reactors use the pressurized heavy water technology (PHWR) developed in Canada. The decision on whether SNF is a waste to be disposed of, or a resource to be reprocessed, has been postponed.
Belgium	7	5,700	2,310	4,560	Belgium will close down all seven reactors after 40 years of operation. The total amount of SNF expected to be generated by the Belgian nuclear power program over its lifetime is about 5,000 tonnes. Belgium has some HLW from an earlier reprocessing campaign.
Canada	22	10,000	27,860	59,400	Eight reactors have been in

Country	No. of Power Reactors 2003	Total MWe from nuclear 2003	Cumulative tonnes of SNF 2000[1]	Cumulative tonnes of SNF 2020[1,2]	Comments
					extended shutdown mode. The owner utilities plan to bring these back into service by 2009, depending on economic and market conditions. Of the eight, two have already restarted and one is currently being brought on line again. Note that CANDU fuel is more voluminous but less radioactive than LWR fuel. The total radioactivity per kW-hr of energy produced is the same.
China	6	4,700	380	6,340	China is expected to produce about 1,000 tonnes of SNF per year from 2020, onwards. China has adopted the closed fuel cycle. Hence, most SNF will be reprocessed. China plans an extensive nuclear program, using a mix of nuclear technologies, including PHWR.
Czech Republic	6	3,400	670	2,880	The total amount of SNF expected to be discharged by the six Czech reactors over their lifetimes is about 3,500 tonnes.
Finland	4	2,700	1,420	2,780	The total amount of SNF expected to be discharged from five Finnish reactors (four operating and one firmly planned) over their lifetimes is estimated to between 2,600 and 4,000 tonnes, corresponding to 40 and 60 years of operation respectively.
France	59	63,100	30,480	50,900	France has adopted the closed fuel cycle. Hence, most SNF will be reprocessed. The reactors currently in operation are expected to produce about 3,500 m^3 of vitrified HLW

Country	No. of Power Reactors 2003	Total MWe from nuclear 2003	Cumulative tonnes of SNF 2000[1]	Cumulative tonnes of SNF 2020[1,2]	Comments
					and 15,000 tonnes of un-reprocessed SNF over their lifetimes.
Germany	18	21,000	9,660	17,510	The German nuclear program was originally based on the closed fuel cycle but direct disposal is now the basic policy and the last SNF will be sent for reprocessing in 2005. Today Germany is phasing out nuclear power. At the end of the German nuclear power program, 22,000 m^3 (including overpacks) of HLW as well as 9,000 tonnes SNF will remain.
Hungary	4	1,800	820	2,070	At present, investigations and discussions on extending the originally planned 30-year lifetime of the reactors by about 20 years are in progress in Hungary. In this case the total amount of fuel expected to be generated by the Hungarian nuclear program would increase from about 1,560 tonnes to about 2,450 tonnes.
India	14	2,700	2,750	15,150	India has adopted the closed fuel cycle. Hence, most SNF will be reprocessed. India plans an extensive nuclear program based on self-sufficiency. Besides LWR, India also has PHWR technology.
Italy	0	0	1,830	1,830	Italy abandoned nuclear power in 1990, as a result of a national referendum. The radioactive waste to be disposed of as a result of the past Italian nuclear power program includes 285 tonnes of SNF and 300 canisters of vitrified HLW resulting from the

Country	No. of Power Reactors 2003	Total MWe from nuclear 2003	Cumulative tonnes of SNF 2000[1]	Cumulative tonnes of SNF 2020[1,2]	Comments
					reprocessing of 1,545 tonnes of SNF.
Japan	53	44,000	17,450	43,740	Japan has adopted the closed fuel cycle. Hence, most SNF will be reprocessed. The total amount of vitrified HLW expected to be generated from reprocessing by 2020 is about 40,000 canisters.
Korea	18	15,700	4,780	22,170	South Korea uses a mix of LWR and PHWR types, with the intention of using spent LWR fuel as feedstock for PHWR elements.
Mexico	2	1,300	220	710	For the time being there are no plans regarding new units or new plants in Mexico although the nuclear option is being kept open.
Netherlands	1	480	380	460	The Netherlands plan to stop using nuclear energy after 2004. The Netherlands will reprocess all of their commercial SNF, resulting in 70 m^3 of HLW at the end of their nuclear program.
Pakistan	2	450	240	1,180	One of the Pakistani reactors is a PHWR bought from Canada.
Romania	1	700	440	4,170	Romania would like to concentrate on PHWR technology. A second reactor of this type will be completed in 2005. Plans for a further three were never completed in any detail.
Russia	27	20,800	17,860	31,770	Since Russia is striving for a closed nuclear fuel cycle, SNF is in principle not considered waste although some SNF will, for technical reasons, be directly disposed of. Russia has ambitious plans for

Country	No. of Power Reactors 2003	Total MWe from nuclear 2003	Cumulative tonnes of SNF 2000[1]	Cumulative tonnes of SNF 2020[1,2]	Comments
					nuclear expansion.
Slovakia	6	2,640	890	2,150	A total of 2,500 tonnes of SNF is expected to be generated by the Slovak nuclear plants through their operating lifetime.
Spain	9	7,800	4,370	7,240	In 1983, the Spanish government adopted an open fuel cycle policy. However, in the past, some SNF was reprocessed abroad, resulting in some 80 m^3 of vitrified HLW. Spain expects to remain with 6,750 tonnes SNF after 40 years' operation of all currently operating reactors.
Sweden	11	9,600	4,130	7,190	Sweden has decided to phase out nuclear energy when the existing reactors reach the end of their lifetime. The total estimated amount of SNF to be disposed of after the end of the Swedish nuclear program varies between 8,000 and 9,000 tonnes.
Switzerland	5	3,200	1,580	2,970	Of the 3,000 tonnes SNF to be generated by Swiss nuclear reactors over 40 years, 1,200 tonnes will be reprocessed, resulting in 130 m^3 of vitrified HLW. The remaining 1,800 tonnes are slated for direct disposal.
United Kingdom	31	13,000	41,430	58,390	The UK is in principle reprocessing all SNF. This will result in 1,520 m^3 of vitrified HLW at end of life of all existing reactors. There are no concrete plans to phase out nuclear power in the UK. On the other hand, there are no concrete plans for new nuclear power stations.

Country	No. of Power Reactors 2003	Total MWe from nuclear 2003	Cumulative tonnes of SNF 2000[1]	Cumulative tonnes of SNF 2020[1,2]	Comments
USA	104	99,000	42,710	82,710	105,000 tonnes of SNF are expected to be generated from current NPPs, if lifetime extensions are included in the projection. The USA also has 230 m^3 of vitrified HLW from commercial reprocessing between 1966 and 1972. No further reprocessing of commercial reactor fuel is currently foreseen.
Total	412	334,740	217,140	432,590	
World Total	444	364,000	228,300	457,090	The difference from the above total is mainly due to reactors in Eastern Europe and Asia.

Note 1) These data are taken (with the exception of Italy) directly from the Energy Information Administration of the USDOE (http://www.eia.doe.gov/cneaf/nuclear/page/forecast/cumfuel.html). They differ in detail from some of the data in the country appendices to this report. This is in part because the appendices are derived from newer documents, e.g. the IAEA Joint Convention submissions; more often it is due to differing assumptions on future nuclear energy production.
Note 2) It is reasonable to estimate SNF arising through to 2020 since this includes all existing and firmly planned reactors; nuclear programs beyond this are less definite.

Most of the SNF produced to date is in storage. The fraction that goes for reprocessing from the countries that follow a closed fuel cycle is less than one third. Storage of SNF always begins under water in the pools at the reactor sites (wet storage). Increasingly, countries are turning to dry storage in vaults or casks, since the pools are filling up and the times needed to implement repositories for disposal are much longer than was originally assumed. Box 1 distinguishes the storage types and Tables 2.2a and 2.2b give an overview of the strategies followed by different countries for storage and for reprocessing. More information on storage technology and choices made by different countries is in Section 2.4.2.

Box 1: Wet and Dry Storage

Wet storage: Storage of the spent fuel in a pool, most usually located on-site at the NPP, where the cooling of the fuel bundles is provided by the pool water, which is circulated in a closed system through heat exchanger and filters. It is the first intermediate stage of spent fuel storage and lasts at least 5-7 years from the moment when the fuel was removed from the reactor. Pool storage has been in operation at reactors for decades.

Dry storage: Storage of the spent fuel in facilities where the cooling of the fuel bundles is provided by air/gas, usually in natural circulation. It represents a possible second intermediate stage of the fuel storage, preceding its disposal in a repository or its reprocessing. There is a large range of choice of dry storage systems. For those seeking to store large quantities of spent fuel for a prolonged period, vaults and silos can give economies of scale; dry casks offer the flexibility of a modular, extendable storage system. The dry storage stage is designed to last several decades.

Table 2.2a: National strategies for storage

Countries with only wet storage facilities for SNF.	Countries using or constructing dry interim storage facilities.	Countries using or planning to use both wet and dry interim storage facilities.
Finland	Argentina	Belgium
Republic of Korea 1)	Canada	Germany
Mexico	Czech Republic	Switzerland
Pakistan	Hungary	United States
Russia	Italy	
Slovak Republic	Romania	
Sweden	Spain	

1) The Republic of Korea plans to construct a central interim storage facility by 2016. A decision regarding whether this will be a wet or a dry storage facility has not yet been taken.

Table 2.2b: National strategies for reprocessing

Countries presently committed to reprocessing of SNF.	Countries that have reprocessed SNF in the past, but have stopped, or plan to stop, doing so.
China	Belgium
France	Germany
India	Italy
Japan	Spain
The Netherlands	Sweden
Russia	Switzerland
United Kingdom	United States

2.2 Legal and Regulatory Framework; Organisational Structures

In order to ensure that the radioactive wastes in any country are managed safely, it is necessary to have an established legislative and regulatory framework and also to create the necessary organisations for implementation and for oversight of waste management operations and facility development. Guidance on the former issue is given in the Joint Convention of the IAEA, which has 33 Contracting Parties (Countries) to date. In Article 19 of the Convention it is specified that the legislative and regulatory framework must provide for:

(i) *the establishment of applicable national safety requirements and regulations for radiation safety;*

(ii) *a system of licensing of spent fuel and radioactive waste management activities;*

(iii) *a system of prohibition of the operation of a spent fuel or radioactive waste management facility without a licence;*

(iv) *a system of appropriate institutional control, regulatory inspection and documentation and reporting;*

(v) *the enforcement of applicable regulations and of the terms of the licences;*

(vi) *a clear allocation of responsibilities of the bodies involved in the different steps of spent fuel and of radioactive waste management.*

The first annual reports to the IAEA on how individual countries are fulfilling their obligations were produced in 2003. These are obtainable on the internet (IAEA 2003); they reveal that virtually all nations have the required legal framework in place.

Establishing the organisations that will be responsible for all aspects of waste management is a larger task. It is also required by the Convention, however, which for example states in Article 20 that:

"Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation[1] of the legislative and regulatory framework referred to in Article 19, and provided with adequate

[1] In this report the term implementer is reserved for the organisation that implements the waste management strategy and program; the regulator is the term used for organisation that implements the legal framework .

> *authority, competence and financial and human resources to fulfil its assigned responsibilities."*

The organisation structures that have been established vary from country to country. It is essential to allocate the functions required by the IAEA to specific bodies and to ensure that the proper degree of oversight and independent review of all activities is guaranteed. A key decision at the highest level is who has direct responsibility for implementation of waste management practices, and most particularly of waste disposal. In some countries the task is judged to be a national responsibility that should be tackled by the Government. Examples here are the USA, where the Department of Energy (USDOE) is directly responsible for disposal of all SNF and HLW (both from commercial and military applications), and Germany or Russia where Government Departments (BfS and Minatom respectively) are directly responsible for all waste disposal.

This allocation of responsibilities can potentially lead to a conflict of interest, since the Government is invariably also ultimately responsible for regulating the safety of nuclear installations. In fact the Joint Convention explicitly requires that:

> *"Each Contracting Party, in accordance with its legislative and regulatory framework, shall take the appropriate steps to ensure the effective independence of the regulatory functions from other functions where organizations are involved in both spent fuel or radioactive waste management and in their regulation."*

In the USA, the conflict is resolved by separating the implementer, USDOE, from the regulator, the Nuclear Regulatory Commission (USNRC) at the highest possible level. In Germany, the specific regulatory function is delegated down to the Länder (~ Federal States) in which the nuclear facilities are to be built. In Canada, the regulator is federal but the operators are provincial, which provides considerable political separation.

In most countries, however, the regulatory task is left to the Government and the implementing task is given to those responsible for the production of the nuclear wastes. This can be done directly by making the nuclear power plant owners responsible, but often these owners join forces to form a dedicated waste management organisation. There are many examples: SKB (Sweden), Nagra (Switzerland), Posiva (Finland), ONDRAF (Belgium), ENRESA (Spain). In some countries the waste management organisations are established by the government, although the financing is normally still provided by the waste producers. Examples here are PURAM (Hungary), ARAO (Slovenia), ENEA or SOGIN (Italy), NUMO (Japan) and most recently NWMO in Canada.

Often, regulatory responsibility for oversight of nuclear activities, and in particular for licensing of facilities, is split. One, largely technical organisation within the government will assess the safety and another, hierarchically higher entity will issue licenses. For example, in the French, Finnish, Swedish and Swiss cases licenses are actually issued by the government Ministry above the regulatory body. Sometimes the regulatory process involves two organisations, one responsible for setting overall standards, the other for translating these into enforceable regulations. This is the case in the USA, where these roles are allocated respectively to the Environmental Protection Agency EPA and USNRC. Finally, the complex of entities involved in regulation often includes various advisory groups whose function is to provide expert advice. These are separate from the advisory groups that many implementing agencies also use to advise on and review national waste management programs.

Table 2.3 gives an overview of the regulatory arrangements in a number of selected countries. The implementing body is the organisation with direct responsibility for siting, constructing and operating waste management facilities. The overall safety requirements are set by the Standards Body and this Body or a further Regulatory Review Body is charged with the oversight function needed to ensure compliance with the standards. Legal permits required for operation of the facilities may come from the Regulator or from a higher Government Agency. Finally, the various Government Bodies often rely on Advisory Groups to provide in-depth technical and/or strategic guidance.

Table 2.3: Overview of some Regulatory Arrangements

NATION	Implementing Agency	Standards Body	Regulatory Review	Permit Authority	Advisory Body to Gov.[2]
Canada	NWMO	CNSC	CNSC	CNSC	
Finland	POSIVA (utility)	STUK	STUK	Council of State	
France	ANDRA	DSIN	IPSN	Ministry of Industry	CNE
Germany	BfS	BMU with RSK, SSK	States (with TÜV, SGS, MA)	States	RSK AkEnd (disbanded)
Sweden	SKB (Utility)	SSI	SKI	Cabinet	KASAM INSITE
Switzerland	NAGRA, GNW	HSK, BAG	HSK	Ministry of Energy	KNE EKRA (disbanded)
USA Yucca Mt.	USDOE	EPA	USNRC	USNRC	NWTRB BRWM
USA WIPP	USDOE	EPA	EPA	EPA	EEG BRWM
UK	Nirex	EA	HSE (management) EA, SEPA (disposal)	HSE EA, SEPA	RWMAC CORWM

(Acronyms are given in Chapter 5)

[2] Note that many of the implementing agencies also have advisory bodies, with varying degrees of independence.

2.3 Waste Management Strategies

2.3.1 The need for a clear policy and strategy

Following establishment of a suitable organisational structure within any country, it is necessary to formulate an overall waste management strategy. This strategy should define how protection of humans and the environment from harmful effects of radiation from wastes is intended to be assured at present and in the future. Increasingly, it is also being recognized that this environmental safety objective must be complemented by an important security aim – i.e. the strategy must consider also how to prevent the malicious use of hazardous radioactive materials. In addition to a reference strategy and plan of action, it is important to identify key decision points, to define how decisions will be taken and to ensure that sufficient resources will be available for all of the actions foreseen.

Extensive guidance on such issues is given in the international consensus documents produced by the IAEA. These include reports on The Principles of Radioactive Waste Management (IAEA 1995a) and on Establishing a National System of Radioactive Waste Management (IAEA 1995b), both of which provided input for the recent Joint Convention. The IAEA emphasises that its Member States should develop an agreed policy for waste management and then a strategy to implement this policy. Crucial elements of the strategy are the description of how all radioactive wastes will be safely managed, what facilities must be implemented to enable this and when these facilities should be operational.

For the case of long-lived wastes, in particular spent nuclear fuel and HLW, the most common strategy culminates in deep geological disposal. Some countries have this solution firmly anchored in their legislation or in their declared government policies. Examples are numerous; they include almost all the countries targeted in this report, e.g. Belgium, China, Finland, India, Japan, Sweden, Switzerland, Russia, the USA, etc.. France is an exception, since the 1990 Law passed there specified that, in addition to geological disposal, two other management options (long-term storage and transmutation) must be kept open at least up to a 2006 decision point. Less formally, some other countries have a policy of keeping other options open, even if geological disposal is the reference scenario (e.g. partitioning and transmutation is followed by Czech Republic, Hungary, Spain, Japan).

The most obvious exceptions to the general commitment to geological disposal, however, are the UK and Canada. In both these countries a review of all conceivable options is underway, following the failure of the repository development plans of NIREX and of AECL to win sufficient public support. The course now being followed in the UK and Canada reflects a different approach to the process of establishing a national strategy, as discussed in section 2.3.3. Canada has, however, done a great deal of work on a generic disposal option, which is available to it if it chooses to pursue this course.

2.3.2 Timetables vary widely

Strategies for waste management are invariably phased or staged, due to the long duration of the activities. Nuclear power stations, the main source of wastes, run for decades; other nuclear technologies will continue, even if nuclear power does not; SNF may be stored for decades, waste repositories take decades to implement and operate; the post-closure safety must be assured for many thousands of years. The timetables are so extended that many programs define a series of phases or stages each of which can last many years. A recent development is the proposal for “adaptively managing” such a staged development (NRC 2003). This implies adopting a flexible process, in which the new knowledge gained at each stage is used to plan the content and duration of following stages - as opposed to attempting to rigorously define all milestones and deadlines at the outset.

Waste management facilities for handling, treating, storing or disposing of SNF following its removal from the reactor are also expensive to implement and difficult to site. However, the quantities of SNF arising are modest compared to most other radioactive and non-radioactive wastes, and experience over 40 years or more has shown that SNF can be safely maintained in interim storage at reactor sites or in centralised facilities. Accordingly, in most countries there is little technical urgency for implementing facilities such as geological repositories.

This is reflected in the long timescales foreseen for such a step in many programs. Japan and Germany intend to operate a deep repository in 2030; Switzerland only in 2050; the Netherlands, Australia, and Slovenia on an indefinite timescale. The countries that plan earliest disposal are the USA (2010), Sweden (2015) and Finland (around 2020). In the first of these, large quantities of SNF have already been accumulated; in the others it is the goal of the implementers to demonstrate in practice, and as soon as is feasible, that safe geological repositories can be constructed and operated. A recent trend is that the security arguments mentioned above are being used to justify more rapid progress towards underground emplacement of nuclear materials. The surprisingly fast decision of the Italian government in late 2003 to rapidly develop a repository in a salt mine is an example of this trend.

Recently, the European Commission of the EU has decided that more pressure to implement waste management strategies should be exerted on its current and future Member States. However, the EC Directive (EC 2002) that was drafted originally proposed unrealistically short timescales (e.g. 2018 for geological disposal implementation). In the latest draft, from November 2003, the deadlines for disposal have disappeared; but instead it is proposed that member states will be required by 2006 to submit to the EC national radioactive waste management plans, including their own deadlines for strategic decisions.

2.3.3 Societal input to policy and strategy

Traditionally, waste management strategies were proposed by the technical nuclear community and submitted to the political leadership for decisions before moving towards implementation. Increasingly, however, public opinion began to influence policy. At first, this happened indirectly by the public exerting pressure on politicians. An early example was the ending in 1978 in France and the UK of reprocessing contracts that allowed the wastes of customers to remain in the reprocessing country. This was a direct political reaction to public opposition focussed through pressure groups.

Many more examples followed as national disposal programs moved into a siting stage and met with sometimes massive public opposition. Examples here are the abandoning of all siting work in Spain, dropping siting work at surface sites in the UK, imposing a moratorium on work at Gorleben in Germany, cancelling the search for a potential site in French granite - all strategic or tactical decisions taken by politicians responding to public pressures.

With time, governments and implementers began to realise that it might be more productive to **actively** seek societal input to the processes of formulating policy and strategy. This has happened at the level of decision making on repository siting, e.g. by emphasising the concept of volunteering in Sweden, France, and Japan. At the most basic level - choosing an overall waste management strategy - the UK and Canada are, as mentioned above, the clear examples in which national policy is intended to be based upon active consultation of the population. In both these national strategies where public involvement is the top priority, this new approach has resulted from the failure of lengthy, costly and high-quality technical programs to gain adequate societal and political support. Section 2.7 below discusses the topical issue of public involvement in waste management. In the relevant appendices, some information on the measures being taken, are recorded.

2.4 Status of Implementation

The maturity of national waste management programs is most directly reflected in the actual facilities that are in operation and in the timetables for further stages. The reporting requirements under the Joint Convention result in complete documentation of such facilities and relevant summaries are included in the Appendix. The principal elements of a complete spent fuel management system include facilities for:

- transport of the material
- storage at the reactors or centrally
- reprocessing if this is the chosen option
- conditioning and disposal of the fuel elements (if this is the chosen option)

The status of such systems in different countries is described briefly below and listed in the appendices.

2.4.1 Transport arrangements

The transport of spent nuclear fuel or high level waste has most commonly been in connection with transfers to and from reprocessing plants in France, the UK and Russia. The transport is normally carried out by specialized companies, with the HLW or SNF packaged in massive, extremely robust shielded containers. The longest transports have been between European reprocessing plants and Japan; these are carried out on dedicated ships belonging to PNTL, a company owned by the reprocessors BNFL and Cogema.

Further SNF transports have been carried out in those countries that operate a centralized storage facility of one of the types described in the following section. The transport casks have been moved by road on heavy trucks, by rail or by a combination of the two. Sweden exemplifies the unusual case of a relatively small country being self-sufficient in transport. This situation is made possible by the fact that all of the Swedish nuclear plants and also the central storage facility, CLAB, are located on the coast and can be accessed by the dedicated motor vessel, Sigyn.

For a large country, the transport infrastructure needed to move SNF from reactors to a centralized storage or disposal facility is very extensive. At present plans are being made for a multi-billion dollar transport system needed to transfer US fuel from the reactors (which are mainly in the Eastern States) to the proposed repository in Nevada. The challenges associated with implementing the transport system are not only technical and economic, but also societal. Despite the long and excellent safety record, and despite the demonstrated robustness of the licensed transport casks, there is often strong public opposition to SNF transports.

This opposition, in some cases, has been driven by opposition to nuclear power, since it is relatively easy to disrupt this part of the spent fuel management system. A clear example of this effect has been seen in Germany. Here, thousands of police officers are required to enable transports to Gorleben, which is a political symbol for nuclear opponents, whereas identical transports to the alternative central storage at Ahaus took place without incident.

2.4.2 Storage strategies

Only a minor fraction of all SNF produced to date has moved to reprocessors or to a centralized storage facility. Most fuel elements are, therefore, still stored at the reactor sites. The facilities used are storage pools in which the fuel elements are kept under water that provides both cooling and radiation shielding. These are built along the reactor and are integrated into the structure and the operational procedures. Most pools, however, were dimensioned on the assumption that the fuel would be moved off site after a few years of cooling.

Since this has not happened (no reprocessing, no repositories), space has become limited. Accordingly, many reactors have modified their pools by installing new fuel racks that permit tighter packing of fuel elements because neutron absorbers are placed between. Even these measures have not been everywhere sufficient, however, and some nuclear power plant owners have constructed additional storage facilities on the site. This additional storage capacity can be in further pools or, as is becoming ever more common, in a dry storage facility. Dry storage is also an attractive choice for countries that plan a long or indeterminate period of storage of SNF.

Dry storage can be in vaults or in casks. Vaults are above or below ground shielded facilities in which SNF is stored in cavities cooled by air or gas. One of the earliest examples was the Magnox Dry Storage Facility at the Wylfa reactor in the UK. Other examples, of a different design, are at Paks in Hungary, Gentilly in Canada and Fort St Vrain in the USA. Dry storage in vaults can be an economical approach if significant quantities of fuel are to be stored.

For small inventories or when the SNF is being produced relatively slowly, it can be more attractive to employ dry storage in individual containers, since this system can be built up in a modular fashion. The containers can be metallic casks, reinforced concrete casks or silos. Metal casks may be designed for dual purposes (storage and transport) or even as multi-purpose containers that can be directly emplaced in a disposal facility. There are various designs of metal casks and these have been deployed in Germany, Switzerland, Spain, the Czech Republic and the USA.

Concrete casks are less expensive than the metal variety. Some use sealed inner canisters containing the SNF. The concrete casks can be placed on pads in the open air, thus providing a simple, expandable storage system. Concrete casks are in use in the USA and in Canada. In the latter country, the low burn-up CANDU fuel makes the concrete cask option attractive since the lower heat conductivity of concrete is of less importance.

Concrete silos can be used to provide shielding of SNF that is contained in a sealed metal container. Vertical silo systems are exemplified by the Canadian AECL system. The NUHOMS storage system developed by Transnuclear, a subsidiary of COGEMA, is an example of a horizontal silo.

All of the storage systems mentioned have been shown to be safe and to be able to be licensed. A recent debate, has however, been initiated by scientists (Alvarez et al 2003a and b) who claim that wet pool storage is a significantly larger security hazard. This claim has been contradicted by the USNRC (2003). The resulting controversy has led to the US Congress deciding that the National Academy of Sciences should prepare a report assessing the safety and security of wet and dry SNF storage.

2.4.3 Storage and Disposal facilities

Table 2.4 presents an overview of the status of waste management programs for SNF or HLW. Storage is in all cases needed; the majority of countries plan for ultimate disposal in deep repositories and the status of the corresponding geological repository project is also summarized.

Table 2.4: Status of Storage and Disposal facilities

Country	Centralised SNF/HLW Storage	Deep Repository Siting Status
Argentina	None planned. SNF stored at plant sites.	Siting has been done in the past. Presently, siting is limited to desk studies due to public opposition.
Belgium	None planned. SNF stored at plant sites.	Siting studies have been done in the past. Presently Belgium is reviewing its SNF/HLW management strategy in general and has no official siting strategy or criteria.
Canada	None planned. SNF stored at plant sites.	Extensive generic investigations and some siting studies have been done in the past. Currently there are no plans for disposal of SNF. All SNF is held in interim storage pending a Government decision on what long-term management method to implement. The Nuclear Waste Management Organisation (NWMO) has a mandate to perform an options study and to make a recommendation to the Government on the method for long-term management of the SNF.
China	Construction of a centralized storage facility started in 1994. The initial stage will have a capacity of 550 tonnes.	In 1985, China initiated a four-step program for the deep geological disposal of HLW. The goal of the second phase, running from 1996 until 2010, is to select one area for further investigation from the candidate areas proposed at the end of the first phase. Although the second phase is not completed, Chinese authorities have already identified one potential siting region, at Beishan, where preliminary investigations are ongoing. The goal is to have an operational repository by 2040.

Country	Centralised SNF/HLW Storage	Deep Repository Siting Status
Czech Republic	None planned. SNF stored at the plant sites.	The Czech Geological Survey performed the preliminary geological screening for a deep geological repository. It was completed in 1992 and resulted in the selection of 27 promising areas in different host rocks. The preliminary site selection was completed in 1998 and resulted in eight sites chosen for further investigation. The further time schedule for the anticipated repository is as follows: • Investigation of eight pre-selected sites by 2005. • Proposal for two final sites by 2015. • Confirmation of the selected site by 2025. • Permit for characterization in and URL by 2030. • Construction licence by 2045. • Commissioning of repository in 2065.
Finland	None planned. SNF stored at the plant sites.	Following a Government decision on spent fuel management, the project for siting of the SNF disposal facility was started in 1983 with a country wide screening. After preliminary site investigation of five areas between 1987 and 1992, a detailed investigation of four sites was performed during the years 1993-1999. Environmental impact assessment and initial safety assessment were carried out at each of the four sites. In 1999, Posiva proposed, in a Decision-in-Principle application, to site the disposal facility for SNF at Olkiluoto in Eurajoki, a couple of kilometres from the NPP. This application was approved by the municipality of Eurajoki in January 2000, the Finnish Government made the Decision-in-principle in December 2000 and the Parliament endorsed it in May 2001. The application for the construction license for the deep geological repository at Olkiluoto is scheduled to be submitted by the end of 2010 and the operating license application around the year 2020.

Country	Centralised SNF/HLW Storage	Deep Repository Siting Status
France	SNF is in principle stored at the reactor sites before being sent for reprocessing. Within the waste nuclear complex of France however, SNF is in practice being shipped between various nuclear installations and stored for shorter or longer periods of time. Examples are the PEGASE pit and the CASCAD dry storage building in Cadarache. In addition, France is envisaging the construction of a new dry storage facility in Marcoule, which would also accept fuel other than that from the local experimental fast breeder reactor.	In 1987, ANDRA initiated activities to site a geological repository and develop plans for four sites (granite, clay, salt and shale). However, there was substantial protest from the public, including environmental organizations and politicians. A new Law was passed keeping options open and volunteer sites were sought for a deep underground laboratory that could eventually lead to a repository. One such lab in clay at Bure is now in operation, but efforts to site a second lab in granite have been unsuccessful. In 2006, the Parliament will discuss and decide on the national policy for management of long-lived high-level radioactive waste. This decision could, but is not obliged to, include the deep geological disposal option.
Germany	There are two designated, operational centralized storage facilities in Germany. However, in order to reduce the number of transports of SNF needed until a national repository is operational, the German utilities are building on-site interim storage facilities.	Preparation for two repositories, one for heat generating waste (Gorleben) and one for non-heat generating waste (Konrad), progressed far towards completion. The Konrad facility has been licensed, although not yet commissioned to start operation. However, the German government that was elected in 1998 decided to suspend further work on these two sites and start the siting process for SNF anew, based on a “blank" map of Germany”. Although criteria for the new siting process have been worked out, the new siting process itself has not started. The main disagreement concerns responsibility for funding any new siting program.
Hungary	Hungary only has one NPP site. At this site, a modular vault dry store named the Interim Spent Fuel Storage Facility has been constructed.	Presently, there is no final decision on the back-end of the fuel cycle. In 2000 however, PURAM prepared a plan where the direct disposal of SNF and other long-lived wastes in a deep geological repository was considered the reference scenario for long term management. Investigations of sites suitable for use as a geological repository have been underway since 1993. As PURAM is presently developing a new strategy for radioactive waste disposal however, the old siting program is not active.

Country	Centralised SNF/HLW Storage	Deep Repository Siting Status
India	Currently, three regional SNF storage facilities are being constructed at different reactor sites to meet expanding storage requirements.	No public information available.
Italy	SNF and HLW are stored at various sites. Until recently, the Italian policy was to have a LILW repository operational by 2010. This repository was also intended to act as a centralized interim storage facility for SNF and HLW. This policy became void with the November 2003 decree on a final repository for all types of radioactive waste.	In November 2003, the Italian government issued a decree authorizing the construction of a deep geological repository for *all types* of radioactive waste near the village of Scanzano Jonico in southern Italy. After two weeks of non-stop public protests however, the Government retreated and modified the decree by removing the name of the village; instead it was laid down that the site for the repository was to be identified within a year. The decree will need to be confirmed by the Italian Parliament by the middle of January 2004.
Japan	Although storage capacity at some reactor sites is becoming scarce, there are as yet no designated central storage facilities in Japan. SNF is stored at the reactor sites before being sent for reprocessing.	Government policy specifies that HLW arising from reprocessing shall be disposed of by geological disposal. Vitrified HLW shall be emplaced in a stable geological formation at a depth of more than 300 m, following 30 to 50 years of interim storage for cooling purposes. NUMO has launched an open solicitation in which they ask communities to volunteer to be the subjects of preliminary siting investigations. Literature surveys will be performed for the areas from which applications are filed, and preliminary investigation areas will be selected from among the areas that volunteer.
Korea	Korea is aiming to construct a centralized SNF interim storage facility by 2016. A decision regarding whether this will be a wet or dry storage facility has not yet been taken. During the first stage, the facility will have a capacity of 2,000 tonnes. This will be expanded in stages to a total capacity of 20,000 tonnes.	Korean policy is that a deep geological repository for SNF/HLW is the best solution. An R&D program was launched in 1997 to establish a reference repository system and to assess the feasibility of a deep geological repository. This research program is conducted by the Korean Atomic Energy Research Institute (KAERI) and shall be completed by 2006 No time schedule for construction and operation of a SNF/HLW repository has been proposed yet.

Country	Centralised SNF/HLW Storage	Deep Repository Siting Status
Mexico	None planned. SNF stored at plant sites.	Presently Mexico is reviewing its SNF/HLW management strategy in general and has no official siting strategy or criteria.
Netherlands	A dry, centralized interim storage facility for HLW – HABOG – has been constructed and is ready to use. The storage is envisioned to last between 50 and 100 years, minimum.	The long-term operation of the HABOG facility allows the Dutch Government to postpone a decision on the final disposal of HLW. Although extensive research was done earlier on disposal in salt domes, there are no concrete plans for a disposal facility for HLW/SNF in the Netherlands and no formal siting process has been defined. The Netherlands is keeping the door open for participation in a multinational repository.
Pakistan	None planned. SNF stored at plant sites.	Because Pakistan does not yet have any policy on HLW/SNF management strategy, no geological repositories are currently planned and hence no siting process has started.
Romania	None planned. SNF stored at plant sites.	Romania is in the process of developing a radioactive waste management program. Disposal in foreseen in either a salt or a hard rock geological formation.
Russia	There is a central (wet) storage facility for SNF from the VVER-1000 light water reactors at Mining and Chemical Combine (K-26). The storage capacity is 9,000 tonnes. Generally, however, SNF is stored at the plant sites until sent to Mayak for reprocessing.	The Russian policy is to dispose of HLW in deep geological repositories. Presently, four facilities in geological formations are considered for storage and disposal of solid radioactive waste or SNF: • Mayak Enterprise • Mining and Chemical Combine (K-26) • Priargunski Mine • Novaya Zemlya Archipelago According to the current plans, geological disposal will not begin until 2025/2030. Final sites have not been chosen.

Country	Centralised SNF/HLW Storage	Deep Repository Siting Status
Slovakia	Slovakia has no plans for a centralized storage facility. An interim storage facility is already in operation at one plant site and a corresponding facility is in the planning stages at the other.	Siting activities have been carried out since 1997, based on the "Slovak Deep Geological Repository Programme". The main activity in the Slovak repository development program has been a preliminary site selection using archive data and maps. This effort resulted in the selection of six sites, with areas of tens of square kilometres each, as preliminary suitable areas. Then in situ geophysical investigations (e.g. boreholes) were initiated to identify areas suitable for further investigation. These investigations will continue for the next five years to narrow the number of suitable sites.
Spain	The current Spanish strategy is to have a centralized temporary storage facility available by the year 2010 and to postpone the decision regarding the definitive management of SNF and HLW until 2010.	A siting process was initiated by ENRESA in 1986. It was defined as a stepwise, systematic screening process designed to gradually narrow down the area in four stages. The first two stages, 1986-1990 and 1990-1995, were completed resulting in the identification of a set of favourable areas for a deep geological repository. The third stage, aiming at the definite selection of suitable sites was interrupted in 1997 as a result of public opposition. Taking into account the postponement until 2010 for decisions regarding the definitive management of SNF and HLW, no further site selection activities will be carried out for the time being. The previous siting process identified a sufficient number of areas on the national territory as being valid, from a geological point of view, to host a deep geological disposal facility. For planning purposes, the Spanish government assumes that a disposal facility could begin operation by 2035.
Sweden	Sweden has an operating central (wet) storage facility for SNF. The storage facility is currently being expanded to be able to store all SNF from the Swedish nuclear power program.	Sweden plans to build one deep geological repository for the disposal of SNF. Feasibility studies for siting of the deep repository were carried out in eight municipalities, three were proposed as candidate sites. After voting in the community councils two sites decided to accept site investigations. The fieldwork programs for the site investigations are now well into their second year

Country	Centralised SNF/HLW Storage	Deep Repository Siting Status
Switzerland	Switzerland has a centralized interim (dry) storage facility for SNF and vitrified HLW, operating since 2001.	The Swiss plans for a national repository call for issuing the required licenses to allow the repository to commence operation between 2040/2050. The ongoing siting work is based on a three-phase strategy that was conceived at the beginning of the 1980s. Phase I: Regional studies based on widespread borehole data, as well as extensive measurements from the surface. Phase II: More intensive investigations to examine the siting potential of smaller areas, selected from the best locations identified during Phase I. Phase III: Deep underground exploration and full characterisation of a candidate site. A preferred siting region has been suggested by Nagra.
United Kingdom	There are no designated central storage facilities in the UK. SNF is stored at the reactor sites before being sent for reprocessing.	The UK abandoned its HLW siting program at an early stage – due to public opposition. It had a major program for siting a geological repository at Sellafield (for LILW not HLW or SNF). After this program failed catastrophically, the UK resolved to re-assess all options for long-term waste management. Since the UK has not yet decided which option (e.g. storage or disposal of HLW and SNF) to adopt, it does not currently have a policy for the siting process or siting criteria.
USA	The USA tried earlier, through a volunteering process, to site a centralised Monitored Retrievable Storage (MRS) facility for commercial SNF. There were no volunteers, however, and all storage is currently at the reactor sites. A private initiative by a company, Private Fuel Storage (PFS) is trying to implement cask storage in Utah.	A formal siting process for a repository was developed under the USDOE siting guidelines (10 CFR Part 960), as required by the NWPA. This process was applied to develop nine sites for consideration for the first repository. In 1986, the President approved three of these sites for characterization. After that, the Amended NWPA passed by Congress selected Yucca Mountain as the only site to be characterized. A site characterization plan was developed for the Yucca Mountain site in 1988 and a very extensive characterization program has been carried out. On July 23, 2002, after the Congressional vote of approval, the President signed the Yucca Mountain Resolution, approving the Yucca Mountain site. A license application is now being prepared.

Country	Centralised SNF/HLW Storage	Deep Repository Siting Status
		Meanwhile the WIPP deep repository for long-lived (primarily military) wastes has been in operation in New Mexico for some years.

2.5 Repository Siting

2.5.1 Overall approach

Over the past decades, there has been an evolution in approaches to selecting specific potential sites for waste management. In the early days of nuclear technology, sites for facilities were commonly chosen to be remote, occasionally because of the military connections, often simply to minimise numbers of directly affected persons. Subsequently, additional facilities were often sited adjacent to existing installations. The necessary infrastructure was available and public acceptance was easier, because of prior familiarity of the locals with nuclear technology.

With time, new locations were needed for different nuclear facilities like repositories, which must fulfil additional, very site-specific requirements. This was the phase in which "expert judgement" was common – often exercised, however, behind closed doors. Groups, primarily of technologists, would in good conscience gather together in order to select specific sites and they would proceed then to plan how best to "decide, announce and defend" their decisions. This was not highly successful. Following this, hope was then placed in developing a logical, traceable procedure, which would narrow in progressively to single sites, which everyone must logically recognize as the "best choice". This kind of approach was described in international documents, e.g. those of the IAEA produced through the 1980's. It would, of course, be an ideal solution for politicians who would have the perfect defence of siting choices. However, the approach is extremely problematic; the element of subjective judgement in narrowing the options remains high enough to fuel disputes even amongst the experts. Moreover, the technical criteria that were proposed for use commonly neglected key societal aspects.

The next approach – and currently the most common – is to use a multi-attribute analysis. This is a technique that attempts to identify all criteria influencing the choice of options, to quantify how well each option matches the criteria, and to combine the quantified scores, using appropriate weighting factors in order to give a ranking of preferences. The scores and especially the weightings can be allocated by different stakeholder groups, which allows one to include also the wider non-technical issues. This approach is promising – provided that there is full transparency concerning the parameters and also the weighting factors, which are employed when combing judgements on the individual parameters.

A final approach is to select potential sites by soliciting volunteer communities. Current siting guidelines from the IAEA (IAEA 1994b) recognize the validity of the volunteering approach with one key provision, namely that *"the selected site provides an adequate level of safety"*. One of the most important developments in the geological disposal field over the past decades has been the methodology for quantitatively assessing the level of safety. This is done by safety analysis or safety assessment. Although not a precise tool, the methodology is mature enough to allow traceable analysis and therefore makes it legitimate **from a safety angle** to bring any potential site into the discussion, regardless of how it was selected.

In summary, approaches tried have varied from rigid technocratic procedures through to totally open volunteering that emphasises social consensus. The recent report from the US National Research Council (NRC 2003) suggests the "adaptive management" approach proposed for arriving at socially and technically acceptable waste management solutions could be applied also at the siting stage. The report, however, also points out that a direct technocratic approach may be more justified if there are urgent concerns with for example the security of spent nuclear fuel.

2.5.2 Approaches used in different countries

In practice, all of the approaches mentioned have been tried; some examples are worth listing. Back in the 1970's, technical experts, in closed session, selected a single site at Gorleben in Germany for HLW disposal; today the legitimacy of this process is still being challenged. Later, in the 1990's, a similar approach in the UK led to the selection of Sellafield as a preferred site for a geological repository for ILW – but this subsequently failed to receive planning permission. The sudden announcement, in November 2003, by the Italian Government that it has selected a site at Scanzano in the south and the 2002 decision of the Australian Government for a LLW site are recent examples of this selection by closed groups of experts. The Swiss selection of Wellenberg in 1993 was done by the implementers comparing it qualitatively with three other shortlisted potential sites. In spite of widespread agreement (including the regulator) on the technical merits of the site, the project subsequently failed, due to lack of sufficient local public support. For a deep disposal site for high-level waste and spent fuel, the preferred region in northern Switzerland has recently been identified – again by a technical, expert judgement approach. Also in other countries, siting for a geological repository has proceeded in a technocratic manner; these include Argentina, Czech Republic and Russia. Important differences exist within these countries in the transparency of the process. For example for its LILW geological repository, Switzerland published the names of all sites looked at as the process narrowed from 100 to 20 to 3 to 1 site. In the UK, on the other hand, the names of sites that dropped out were kept secret.

In the USA, technical multi-attribute analyses yielded three potential sites, and a political decision by Congress narrowed in to the single Yucca Mountain site. Although there is continued opposition at State level to the project, USDOE is currently preparing a licence application for repository implementation at the site. Following a wide volunteer solicitation process that led to little success, the staff at SKB in Sweden themselves identified promising sites – but made commencement of a site characterisation program contingent upon receiving the consent of the local community. This approach has been successful in identifying two potential sites. In Finland, the optimal situation has been reached. After a cautious staged approach looking at various options, attention was focussed on two communities, which actually competed to host the repository. One of these, Olkiluoto, is now being developed. Open volunteering was successful in France in identifying the potential site in clay at Bure, but has not yielded the desired second site in granite. Finally, Japan has embarked upon a very wide solicitation process for volunteers, with comprehensive data packs being distributed to over 3000 communities. The results of this approach are awaited with interest; a first potential volunteer entered into discussions with NUMO at the beginning of 2004.

On this topic of siting repositories, a valuable reference document has been produced relatively recently by Lawrence Berkeley Laboratory in the USA. The document, "Geological Challenges in Radioactive Waste Isolation; third world-wide review", contains a very instructive summary of the status of programs in a large number of countries (Witherspoon and Bodvarsson 2001). The countries closest to implementation of deep geologic repositories are the USA, where a license application is being prepared for the Yucca Mountain site, Finland, where Olkiluoto in Eurajoki has been chosen as disposal site, and Sweden, which has narrowed the siting process down to two final potential locations – Simpevarp and Forsmark – where the site investigations are well underway. Other countries working, at least in principle, towards geological disposal are numerous; they include Switzerland, Japan, Belgium, the Czech Republic, Hungary, Spain, Argentina, South Korea and countries of the former Soviet Union. The progress being made in these countries varies dramatically, however, and (as previously mentioned) in a few countries, the concept of geological disposal is being questioned once again.

2.5.3 Siting Criteria and their Application

However sites are arrived at, they must fulfil certain technical criteria to be accepted as suitable, and much work has been done internationally and nationally on establishing such criteria. Further non-technical and social requirements are discussed at more length later in section 2.7. The program and procedures of the implementer in the siting area can be subjected to external requirements at four different levels (see Chapman and McCombie 2003). These are:

1. *International requirements.* Principally, these comprise regional (e.g. EU) legislation on environmental impact assessment (EIA), and the various international agreements such as the Joint Convention.

2. *National policy and programmatic requirements.* These could include, for example, defining the level of involvement of Government, planning authorities, regulators and the public; the number of candidate sites to be considered; the timetable to be adhered to.

3. *Specific site selection requirements.* These might cover, for example, looking at a range of host-rock types and geological environments before choosing a preferred

host, or avoidance of resources to ensure that site investigations address specified issues.

4. *Site characterisation requirements.* These might specify which data to collect for safety assessment, the QA measures to be applied and measures to avoid negative impacts on site characteristics.

The involvement of different political and regulatory bodies at each stage in the siting process varies widely from country to country and in some countries there is a confusing and unhelpful mixture of requirements in these different areas.

The IAEA most recently established broad siting guidelines for a deep waste repository in 1994 (IAEA, 1994b). This 'Safety Series' report was intended both for implementers and for regulatory agencies involved in developing standards, criteria and specifications. The IAEA also provides a set of general site selection guidelines which can be used as one component (along with safety, feasibility, social, economic and environmental considerations) to develop practical national guidelines, should these be considered necessary.

The IAEA guidelines have been adopted to varying extents in national regulations but the level of detail in each country is highly variable. Only the Spanish regulatory guidelines are a close match to the details provided by the IAEA report. Other countries have chosen to be less prescriptive. They prefer instead to stipulate only broad 'common sense' factors that should be accounted for in siting, and to base their regulations on the end point of actual performance: ensuring that a proper safety case is made that meets radiological performance measures. The most recently started efforts to develop siting criteria are those of the German AkEnd group (AkEnd 2002). In 1999, following widespread controversy about the two potential sites chosen for deep geological disposal in the 1970s and 1980s (Gorleben and Konrad), the German government set up the group to develop new criteria. The process of applying these criteria to a siting process in Germany is currently stalled due to disagreement, primarily on the method for financing the search.

2.5.4 Number of sites at each stage

A specific siting issue that is of great importance concerns the number of sites to be investigated at each siting stage. There is no obvious a priori way of determining how many potential sites should be considered. This depends primarily upon judgements on the probabilities of candidates proving to be ultimately unsuitable, and upon the costs entailed. Multiple sites increase the chances of having at least one success. Multiple sites allow choices; i.e. they give flexibility to the program and prevent unexpected results at any site necessarily leading to a major realignment of effort. However, exploration of sites, especially if this involves investigation of the deep geology, is an expensive undertaking. It is noteworthy that, even in the USA, a full characterisation program for three sites was found by Congress to be too expensive, which resulted in the political choice of the single Yucca Mountain site (USC 1987).

Approaches here have also differed between countries. In particular, for the most expensive stage involving underground exploration using a deep shaft, concepts vary. In countries like Finland, Switzerland, Belgium and Spain the objective has always been to sink a shaft at only one site, unless the results at the first site chosen prove that further site searching is necessary. In Sweden and in France, the original plans were to have a deep shaft for investigation of at least two potential sites. Sweden has since moved away from this concept, partly because there has already been expensive underground exploration at two underground laboratory sites. In France, the policy still involves underground exploration at two sites, one in clay and one in crystalline. However, the crystalline site has not yet been identified and work at the clay site at Bure in northern France is significantly advanced. In Germany, two sites have already been investigated at depth. The Gorleben salt dome in Lower Saxony has been the subject of a major site exploration program that has cost more than 1 billion Euros. The Konrad iron mine has been extensively investigated for a potential disposal of non-heat producing wastes. However, mainly for societal reasons, the government in Germany charged the new group (AkEnd) with the development of a new siting approach, as described above.

2.6 Costs and Financing

2.6.1 Costs

The costs of waste management, in particular for spent fuel and HLW, have become a topic of increasing interest and controversy over the past several years. Originally, relatively little attention was paid to this issue, since the contribution of these back-end costs to total fuel cycle costs is relatively small. Typically, for nuclear electricity 60% of the cost represents capital costs, 20% operation and maintenance and 20% fuel costs (NEA 2003a). The back-end costs alone are then typically 5-10%, or up to about half the overall fuel costs.

On an absolute scale, however, the costs are high. The front-end of the most common nuclear fuel cycle (uranium purchase, conversion, enrichment and fuel fabrication) and the back-end (transport, reprocessing if done, encapsulation of SNF or HLW and disposal) cost each about the same, namely USD 800-900 per kg of uranium (NEA 1994a). When one considers that a large LWR plant (1000MWe) will use around 25 tonnes per year, this shows that fuel cycle costs are tens of millions of USD per year. The mass or volume of spent fuel from a PHWR (e.g. CANDU) is three or four times that of a LWR, on a per kWh basis. The radioactivity is correspondingly less. The total radioactivity per kWh is about the same. The cost of a repository probably depends more on radioactivity than on volume of fuel, but that will depend on the design. These factors have to be taken into account in comparisons. A comparison based on cost per unit mass of spent fuel could be misleading.

For the front-end of the nuclear fuel cycle estimates of this sort are fairly reliable, since none of the component prices vary widely. In fact, the low dependence of nuclear power costs on the cost of the raw material uranium is one of the strengths of this energy form. For back-end costs, there are much greater problems. The only currently feasible back-end strategy that does not involve continuing expenditure for indefinite storage is deep geological disposal - and there has not yet been a deep repository implemented for disposal of HLW or SNF. Disposal entails very large capital costs up front and, as long as the discounted capital costs are greater than the discounted annual expenditure for storage, it can pay to continue storing.

The numerous estimates of future costs that have been made by different national programs vary very widely. Some examples are given in the table below, which is based on reference (IAEA 2002).

Table 2.5: Estimated Cost of HLW/SNF Management

Country	Cost in MEuro[3]	Comments
Belgium	290-580	Disposal of HLW. Direct disposal option.
Czech Republic	1,472	This estimate includes the cost of R&D, SNF repository and associated programs (e.g. public relations).
Finland	1,287	This estimate includes the costs of SNF storage and transport, repository and associated programs (e.g. licensing) in the future.
Japan	22,250	The estimate includes the costs of R&D, a repository with the capacity to dispose of 40,000 canisters of vitrified HLW, management and tax.
Spain	10,000	This estimate includes the costs of SNF/HLW and LILW management and decommissioning.
Sweden	6,466	SNF disposal. The estimated future costs include funds for decommissioning of NPPs.
Switzerland	7,238	This estimate includes costs for transport, storage and management of SNF and disposal of LILW.
USA	48,239	This represents the Department of Energy's May 2001 total system life cycle cost estimated to dispose of all planned SNF expected from currently operating and shutdown nuclear power plants (~83,500 t HM), as well as HLW from defence activities. The total cost estimate includes the costs of repository, transportation and other associated programmatic costs.

The differences in cost estimates can be caused by many factors. Most important, perhaps, is that the different programs do not include the same set of items in their cost lists. For example the USA estimate includes all aspects such as transport, licensing, public involvement, etc.; the Belgian figures are purely for disposal in a deep repository. These differences make a direct comparison of the figures problematic, but some lessons

[3] The costs given in this table are based on reported cost estimates from around 2000; currency conversion rates from 2003 (as given in the country appendices) have, however, been used. The most important conversion ratios here are: 1 Euro = 1.61 Canadian Dollars = 1.22 UD Dollars (2003).

can be learned by examining the orders of magnitude. Other major differences are caused by the quantities of SNF or HLW that are assumed to be emplaced in the repository. Although this makes a large difference, there are economies of scale, so that large programs end with lower unit costs. For example, the NEA 1994 report gives for undiscounted costs of encapsulation and disposal of SNF, the following figures:

Table 2.6: Encapsulation and Disposal Costs of SNF

Country	Quantity in tonnes	Costs
Finland	1,840	413 USD/kg
Sweden	7,840	410 USD/kg
USA	96,000	104 USD/kg
Canada 1)	191,000	46 USD/kg

1) Again, Canada's spent fuel has lower specific reactivity but correspondingly higher volume, which makes the unit costs lower.

Although these figures have been since revised, they demonstrate well the fact that the fixed (capital) costs associated with implementing a deep repository are large relative to the variable inventory-dependent (operating) cost elements.

Other factors also complicate a comparison between countries, e.g. the conservatism of each set of estimates, regulator requirements, fluctuation in exchange rates, etc. When planning ahead for disposal, however, all of these points are insignificant in comparison to the influence of the timetable for implementation. Many countries plan to implement geological disposal only some 30-50 years or more in the future. The economic advantages of delaying the high expenditures involved depend sensitively on the assumed future discount and interest rates - but they can be large. The net present value (NPV) of a disposal facility - i.e. the funds that one must set aside today to be able to meet the future implementation costs - depends on the difference between inflation rates and rates of interest. Even at the low real[4] rates of around 2% normally assumed, to finance a disposal project 50 years from now, one needs today only to invest less than half the final cost.

2.6.2 Financing

The preceding discussion on costs of future activities leads directly to consideration of how these costs should be met. In the nuclear industry, the fundamental principle for financing is that "the polluter pays" (In practice, the nuclear industry largely contains its waste; there is in fact almost no pollution and the principle really should read "The potential polluter pays to avoid pollution"). This means that in almost all countries, the producers of radioactive wastes must provide the funding for their management. In most

[4] Difference between achieved rate of return and inflation.

cases this is regulated by establishing a fund which accumulates the resources that will be needed in the future for long-term management of wastes (EC 1999).

Because the back-end is a relatively small part of total costs and because of the interest expected to be earned, the contributions required are relatively modest. For example, the USA levies 0.001 USD /kWh (€ 0.0008) on nuclear electricity production, Sweden 0.01 SEK (€ 0.001), Japan 0.13 Yen (€ 0.001) Czech Republic 0.05 CZK (€ 0.002); Spain 0.8% of the electricity price, Bulgaria 3% and Slovakia 6.8%. The differences reflect not only differences in national economics but also in the exact cost items covered (e.g. decommissioning is sometimes included and sometimes not).

Some countries do not have an explicit levy on kWh of electricity, but they require the waste producers to set aside sufficient funding. This is the case in Switzerland where government controlled trust funds exist for both decommissioning and disposal. It is also the case in Germany, although there the funds remain with the electrical utilities. The accumulated funds in some national programs are already substantial, e.g. in Germany 25-30 billion Euros, in the USA 10-15 billion USD, in Switzerland ~6 billion CHF (EC 1999). The management of the accumulated funds also varies from country to country. Some examples are:

Table 2.7: Management of payments

Country	Management of payments for waste management
Belgium	Interest-bearing fund, managed directly by ONDRAF. Funds are raised through annual contributions during the 20 first years of the plant lifetime and together with the interest accrued, these contributions must, in 30 years from plant startup, amount the decommissioning costs evaluation. The interest calculation is based on rates customarily used for present worth calculations. Annual contributions to the fund are taken into account in the kWh costs of electricity.
Canada	The Nuclear Fuel Waste Act requires nuclear fuel waste producers and to establish trust funds to finance the long term management of nuclear fuel waste. These funds will accumulate and may only be used for the purpose of implementing the management approach selected by the Government of Canada, once a construction or operating licence has been issued under the Nuclear Safety and Control Act. These legislative obligations are the responsibilities of the individual companies named, and not the NWMO
France	Waste producers (EdF) build up provisions in their own books. A fee is paid for each waste package delivered to a disposal facility. For already established repositories (LILW), this fee is established yearly per cubic metre and is negotiated yearly between the waste producers and ANDRA. Pre-financing of new repositories is based on long-term forecasts on waste generation.
Germany	Reserve funds built up by waste producers; tax-free and can be invested in their own businesses.
Netherlands	Capital growth fund directly managed by COVRA. Funds are provided for by the utilities. COVRA receives a fixed yearly sum from the utilities. In addition, COVRA receives a sum that depends on the costs of transport, handling and storage of the waste volume. This volume is calculated on a yearly basis.

Country	Management of payments for waste management
Spain	The costs arising from waste management and the dismantling of nuclear power plants are fully covered by specific funds, collected via the electricity tariff. Calculation of these costs is carried out by ENRESA, on the basis of an operating lifetime of 40 years for the reactors. The Ministry of Energy establishes annually the percentage of the electricity price to be levied for this purpose. The money is managed by ENRESA and is invested in financial securities in order to earn interest. The total amount associated to each power station at the end of its service lifetime, plus the interests, have to cover the whole cost of waste disposal and plant dismantling.
Sweden	A fee is levied on the nuclear electricity production and collected in a segregated Fund (the Nuclear Waste Fund) managed by SKI. The levy is determined each year by the Government and is based on the cost calculations submitted by SKB to the SKI. The cost calculations are based on the assumption that all nuclear power plants will be operated for at least 25 years.
Switzerland	All NPPs have to make annual payments into a waste management fund, such that at the end of a 40-year period of operation, the total amount accrued is enough to cover all future costs of waste treatment and disposal. The waste management costs are updated every 5 years, or after important changes in governing conditions. Finance specialists under the supervision of a joint government/utility board perform the fund management. The costs of waste disposal are therefore included in the production costs of the plants.
United Kingdom	A new Nuclear Decommissioning Agency has been set up to manage all future liabilities. Provisions for the costs of discharging the public sector nuclear liabilities are built up in the balance sheets of the companies concerned.
United States	The radioactive waste management program for SNF is funded by the waste generators and owners through a fee on the commercial generation of nuclear power. This fee, which is assessed at 1 mill per kilowatt-hour, is deposited in the Nuclear Waste Fund. The Government can use the Fund for current expenditure purposes.

2.6.3 Allocation of Costs

However the total costs for long-term management of spent fuel and HLW are to be recovered from the producers, there will be a question of the allocation of these costs. The objective is to find a mechanism that ensures all costs are covered, is simple to operate and is fair to all participants. Various approaches have been proposed ranging from simple dependence on energy produced, through mechanisms depending on volumes or masses of spent fuel, to complex proposals accounting for specific radionuclide contents.

2.7 Public Involvement

2.7.1 Increased Recognition of the Need for Public Involvement

Over the past decade or more, there has been a steadily increasing emphasis in waste management programs on the necessity for involving the public in the decision making process. Earlier, in waste management as in the nuclear industry in general, a wealth of information had been provided to the public - but direct involvement in decision processes was rare or non-existent. This lack of involvement was seen to lead to delays or even major setbacks in national programs. The most pronounced example may be the Canadian program in which the Seaborn Panel (CEAA 1998) came to the conclusion that

> *"From a technical perspective, the safety of the AECL concept has, on balance, been adequately demonstrated for a conceptual stage of development, but there is still an outstanding requirement for its demonstration from a social perspective. As it stands, the AECL concept for deep geological disposal has not been demonstrated to have broad public support. The concept in its current form does not have the required level of acceptability to be adopted as Canada's approach for managing nuclear fuel wastes."*

The Seaborn panel was itself an attempt to involve the public in the decision-making process. It was intended to ensure that no actual site would be considered before a generic disposal concept had been found to be scientifically acceptable. It was not anticipated that social acceptability would be required at this stage.

In other programs also, for example, in Spain, the UK, Switzerland, Germany, public opposition - most often to specific siting proposals - led to programs being delayed or stalled.

The importance of achieving sufficient societal consensus through increased public involvement was recognized in overview documents such as the 10 year review prepared by the NEA (NEA 1999) or the report by the US National Research Council (NRC 2001) which stated that

> *"Today, the biggest challenges to waste disposition are societal…. Difficulties in achieving public support have been seriously underestimated in the past and opportunities to increase public involvement and to gain public trust have been missed."*

The follow up to this NRC report was a further report on staged repository development, which pointed out very clearly that direct involvement of the public in decision processes was needed for an effective adaptively managed approach to development (NRC 2003).

At national and international levels, therefore, measures have been increasingly taken to improve the situation. Some national programs, such as that in Sweden, started early with direct public involvement. SKB agreed to voluntarily accepting that a public veto on siting would be regarded as binding on the repository implementer. This may be one reason for their progress. Others, such as UK Nirex, initiated very extensive public consultation processes after suffering major setbacks - in the UK case with the loss of the Sellafield site.

At an international level the lead role was taken by the NEA in Paris. In 2000, the NEA launched a Forum on Stakeholder Confidence (FSC) to address *"a variety of topics ranging from evolving stakeholder identity, evolutions in participatory democracy, stakeholder identity and trust in the institutional framework, to the role of open dialogue in all aspects of radioactive waste management"* (NEA 2003b). The FSC has had workshops in France, Finland, Canada and Belgium. The above reference document, "Public Information, Consultation and Involvement in Radioactive Waste Management" contains a summary of the relevant activities undertaken in participating countries.

The importance of public involvement is conclusively demonstrated by the fact that it is now a formal requirement in the laws of some countries and in international agreements. In the European Union, Member States are required to submit Environmental Impact Assessments (EIA) for major projects, including radioactive waste facilities, and these EIAs require public participation. Nationally various countries have introduced specific policies or laws requiring public participation. Examples are the Canadian Nuclear Safety and Control Act and the US Nuclear Waste Policy act.

2.7.2 Specific approaches employed for public involvement

As can be gathered from the country appendices, virtually all waste management programs today invest substantial effort into improving communication with the public. The previous discussion made clear that the public generally wants more than "communication" in the sense of a one-way flow of information. It wants to have input into the process, assurances that its input is understood and acted on, and participation in the decision process. In the following summary we note the main approaches employed.

Publications, lectures, information meetings:

These "traditional" approaches, aimed more at transmitting information than at dialogue, are pursued in all waste management programs. Many implementers and regulators produce their own published report series (e.g. USDOE, USNRC, SKB, Posiva, Nagra, ENRESA, etc.). Today these are increasingly augmented by dedicated web sites, many of which then also provide means for public feedback. All implementers also hold public information meetings, most often in connection with efforts to site nuclear facilities for storage or disposal.

Formal reviews, public enquiries, hearings:

Many countries have requirements for a formal procedure that allows all stakeholders to put their views on key issues. For example, in the UK, a public enquiry was held on the Sellafield project; in the USA, the regulator seeks public input via a rule making process; in Germany extended formal hearings were held in the repository licensing process for Konrad; in Sweden and Finland (Posiva 1999) the EIA procedure ensures that the public is involved.

Face to face meetings; site visits:

In countries with facilities that interest the public, site visits have been found to be a valuable vehicle allowing interactions. Visits can be to operating repositories or chosen sites, such as SFR in Sweden, VLJ in Finland or Yucca Mountain in the USA. Countries with underground rock laboratories (e.g. Sweden, Belgium, Switzerland) also encourage visitors. Technical waste management facilities such as interim stores, reprocessing plants, etc. also are open to the public. In addition, in many programs the waste management specialists go out to the public. In Sweden and Finland, the ship “Sigyn”, when not transporting nuclear fuel or wastes, tours ports carrying nuclear exhibits and nuclear experts. In Switzerland, waste management activities are presented at trade fairs throughout the country. In Japan, the volunteer siting process has been presented at numerous communities throughout the entire country.

Interactive workshops, focus groups:

Organisation of workshops on specific topics has been a feature of various public involvement programs, for example in Canada, Sweden, the USA and the UK. These workshops allow more in-depth treatment of technical or societal issues. The use of focus groups to guide implementers or regulators in specific topics has also been common in many countries.

Local committees:

Several waste organisations have formed local committees to participate in decisions involving developments at a chosen site. In Belgium these are called “local partnerships”; in Sweden, the municipality council is a reference group in the EIA forum; in the Swiss HLW program local oversight committees, including also representatives of the community, were formed for each borehole exploration site; the local committee IEEG, in New Mexico in the USA played an important role in the development of the WIPP repository. In Canada, the Siting Task Force for low-level radioactive waste dealt with potential volunteer communities through local committees.

Independent advisory or expert groups:

In some cases, independent groups of interdisciplinary experts including social scientists have been established (most often by government initiatives) to advise on program strategy. In Germany, the AkEnd group was set up to propose a process for nominating potential repository sites as an alternative to Gorleben; the Swiss EKRA group advised the Government on overall strategy; in France the national committee CNE does likewise; in the UK the similar RWMAC committee is at present being replaced by a new group, CORWM.

Dedicated projects, consultation exercises:

To improve communication with all stakeholders including the public, dedicated projects have been established. For example, the RISCOM and DIALOGUE projects were both initiated in Sweden, with the former being later expanded under the auspices of the EC.

In the UK, possibly the most elaborate public consultation exercise was started by Nirex with the publication of a document, “The Way Forward”, circulated to 50,000 stakeholders. The most direct approach to integrating local communities into siting decision is currently being followed by the Japanese waste management organisation, NUMO. Siting efforts for the HLW should begin with volunteer communities coming forward and engaging from the start with NUMO in a partner relationship.

Of course, the above list is not exhaustive. In particular it should be noted that the normal processes of democratic government can also play a role – referenda, parliamentary committees, congressional hearings, etc.

2.7.3 Public Involvement in Discussions on Ethics.

A point of particular interest is the public’s view on the ethical issues associated with waste management and waste disposal in particular. The nuclear community addressed ethical questions quite early in the development of waste management strategies - but normally without involving the public. Early consensus documents produced by the IAEA, the NEA, etc. recorded the experts’ views that avoiding passing on burdens to future generations was the primary goal (intergenerational equity), and this was fixed into recommendations and principles. Some national programs had organised prior to the work of the international agencies special national meetings to discuss the relevant ethical issues. This happened, for example, in Sweden, Switzerland and Canada. In Canada, the recent Nuclear Fuel Waste Act explicitly requires consideration of ethical and social issues.

The issue of intergenerational equity as formulated above was challenged by the Swedish advisory committee, KASAM, which postulated that maintaining future freedom of choice was of at least equal importance. This led to increased emphasis on long-term surface storage and on disposal options with retrievability. A further amendment to the weightings on different ethical principles resulted from increasing dialogue with local communities in siting programs. The principle that gained weight was that of fairness across existing society (intragenerational equity). This leads one to avoid unjustly burdening weaker elements of society and to ensure that communities that do agree to offer a service are properly compensated for doing so.

This point of agreeing compensation has resulted in some of the most direct public participation in waste management programs. Examples of successful dialogue in this question are to be found in Finland at Eurajoki (for an SNF repository), in Switzerland at Wolfenschiessen (for a LILW repository) and at Würenlingen (for an interim store), in France at Bure (for an underground laboratory) and in the USA at WIPP (for a TRU repository). In other situations, however, dialogue between implementer and potential host community has been difficult or impossible - the obvious example being in the USA, in Nevada.

The nuclear community was slow to recognise the importance of open discussion on ethics. Eventually, however, it did and a Workshop held on the topic in Paris in 1994 led to the publication of a "collective opinion" on the topic (NEA 1994b, NEA 1995)

2.7.4 Public Participation in Siting

Public participation in siting processes is an especially important concept in long-term waste management today. Earlier public information was thought by many to be sufficient; today the public in many countries wants also to be part of the decision-making process. How should the public and other stakeholders be involved? Although there is universal acknowledgement that involvement of interested and affected parties is absolutely necessary, there is no consensus on how it is best achieved. Recently there have been various new attempts to broaden participation, e.g. in Sweden, Canada, Switzerland, Germany, the UK and internationally (e.g. in the NEA). The degree of public participation in site selection varies greatly from country to country. Sometimes, especially in the past, it has been a closed process done without any public input. Today, it is obvious that processes must be open and transparent. Furthermore, there is increasingly an effort being made to seek input from the public on the siting process. In order to provide specific input the public may need independent technical advice, which leads to the question of the sources of funding for expertise provided to potential host communities.

A particular point that has arisen in many countries concerns the issue mentioned above of compensation of a siting community. Originally, there was some reticence in many countries to offer compensation, the feeling being that this would be looked on as a form of bribery to compensate for a community accepting a dangerous facility. Increasingly it is recognized that this is not the case. Any community which accepts a facility that will serve the common good of a larger public is entitled to be compensated for providing this wider service. Accordingly, in some (but not all) countries, direct compensation of the host community is now foreseen. In fact, in many countries compensation already begins during the site selection stage, i.e. all potential siting areas will receive some form of compensation. Specific examples of compensation schemes for hosting a repository have been discussed in various countries including the USA, Switzerland, Taiwan, Canada, etc.

A further critical issue in dealing with the public concerning siting of geological repositories, is that the perspectives of both technical experts and of public citizens must be factored into the equation. Subjective perceptions can influence the outcome of siting debates just as much as objective facts. As mentioned earlier, a purely technocratic or objective approach is a myth which has not been able to be realized in any country. In all programs the importance of listening to the subjective opinions and the anxieties of the involved stakeholders has been increasingly recognised. (This idea has been concisely summarized in the aphorism, "In politics, perception is the reality".)

The last point to be made with respect to public participation is that this is increasingly acknowledged to be a duty not only of the repository implementer but also of the regulator. In most countries the regulator tries to be, and is in fact perceived as, working on behalf of the public. Therefore it is important that the regulator also have an explicit program for interaction with all stakeholders including the public. Positive examples of national regulators with strong public involvement programs are the EPA in the USA and SKI in Sweden.

2.8 International Cooperation

2.8.1 Sharing knowledge and experience.

As pointed out in the introduction to this report, there has always been more readiness to share knowledge in waste management than in other nuclear areas where commercial or military interests played a greater role. The countries that initiated specific programs in the 1980s quickly formed a network of bilateral and multilateral agreements. In the appendices, the impressive extent of this network can be seen. The cooperation was encouraged through the international organisations described in Chapter 3. The NEA provides multiple fora for OECD countries engaged in radioactive waste management. The EC and the IAEA do likewise, with the latter placing special emphasis on transferring necessary know-how to developing countries. The major implementing bodies have also formed a dedicated organisation, EDRAM, aimed at ensuring good coordination.

There are very many examples of multinational technical projects that are undertaken to pool resources and widen the scope of research. An important sub-set of these takes place in underground research laboratories (URL) in different countries. URLs can be location independent or site specific; they can take advantage of already existing excavations or be purpose built from scratch in a particular host rock.

The cheapest and simplest form of setting up a URL is to take advantage of already existing underground excavations where underground void space is available or can be easily excavated. Well-known examples of these are, for example, closed iron, potash or uranium mines and abandoned railway, highway or hydro tunnels. Common for these URLs are that the geological formations have been identified as including a rock type that is of generic interest for waste disposal and that can deliver rock type specific information which is independent of the actual geographical location of the rock formation itself.

If a country or group of countries want to perform underground research work on a particular rock category but are not able to locate suitable existing facilities, or wish to study an undisturbed site, then a purpose-built URL will have to be constructed. Examples of these are the HADES URL in plastic clay in Belgium and the Busted Butte facility in bedded tuff in USA. These URLs also give information that is rock type specific but location independent.

A third category of URLs is the site specific facility. These are constructed at locations that have been identified as actual potential sites for final repositories. They can also be abandoned existing excavations that have been identified as particularly suitable, e.g., the former Konrad iron mine in Germany, or, more commonly, they will be at a new site believed to host a particularly suitable geological formation, like, e.g., the ONKALO URL in Finland or the Gorleben salt dome in Germany.

Tables 2.8a, b and c give an overview of the diversity of such facilities in NEA countries (NEA 2001). Because access is invariably open also to other countries than the host, it is possible for national programs to study different host rocks before making their own choice.

Table 2.8a: Generic URLs in NEA Member countries that take advantage of pre-existing underground excavations

URL	Host rock, location, depth	Organisation, remarks	Other NEA countries cooperating in research
Asse Mine	Permian rock salt anticline; Germany; several mining levels between 490 and 800 m, mined cavern at 950 m.	GSF; galleries in former potash and rock salt mine, demonstration facility for LLW and ILW disposal from 1965 to 1978, R&D facility until 1997, backfilling of unused excavations underway.	France, Netherlands, Spain
Tono	Sediments; Japan.	JNC; galleries in former uranium mine, operating since 1986.	Switzerland
Kamaishi	Granite; Japan	JNC; galleries in former iron-copper mine, completed in 1998	Switzerland
Stripa Mine	Granite; Sweden; 360-410 m.	SKB; galleries in former iron mine, operated from 1976 to 1992.	Canada, Finland, France, Japan, Spain, Switzerland, UK, USA
Grimsel Test Site (GTS)	Granite; Switzerland; 450 m.	Nagra; gallery from a service tunnel of a hydroelectric project, operating since 1983.	Czech Republic, France, Germany, Japan, Spain, Sweden, USA
Mt. Terri Project	Opalinus clay (hard clay); Switzerland; 400 m.	SNHGS; gallery from a highway tunnel, initiated 1995	Belgium, France, Germany, Japan, Spain
Olkiluoto Research Tunnel	Granite (tonalite); Finland; 60-100 m.	Posiva; Tunnel adjacent to the Olkiluoto repository for LLW, operating since 1992. Research relevant to spent fuel disposal at this or other sites in Finland.	Sweden
Climax	Granite; USA; 420 m.	USDOE; drift mined from existing excavations; spent fuel disposal experiments	

		conducted 1978 to 1983	
G-Tunnel	Tuff; USA; >300 m.	USDOE; tunnel of weapons-testing excavations; operated from 1979 to 1990.	
Amelie	Bedded salt; France.	ANDRA; galleries in potash mine, operated 1986 to 1992.	
Fanay-Augères	Granite; France.	IPSN; galleries in uranium mine, operated 1980 to 1990.	
Tournemire facility	Sediments (hard clay); France; 250 m.	IPSN; former railway tunnel and adjacent galleries, operating since 1990.	Germany

Table 2.8b: Generic URLs in NEA Member countries that have been purpose-built

URL	Host rock, location, depth	Organisation, remarks	Other NEA countries cooperating in research
High-Activity Disposal Experiment Site Underground Research Facility (HADES-URF)	Boom clay (plastic clay); Mol/Dessel, Belgium; 230 m.	GIE EURIDICE; shaft sinking began 1980, operating since 1984 and extended 1998-9	France, Germany, Japan, Spain
Whiteshell Underground Research Laboratory (URL)	Granite; Lac du Bonnet, Manitoba, Canada; 240-420 m.	AECL; operating since 1984.	France, Hungary Japan, Sweden, United Kingdom, United States
Mizunami Underground Research Laboratory	Granite; Japan.	JNC; borehole drilling underway.	Switzerland
Horonobe Underground Research Laboratory	Sedimentary rock; Japan.	JNC; construction approved 2000.	
Äspö Hard Rock Laboratory	Granite; Sweden; several depths between 200 and 450 m.	SKB; operating since 1995.	Canada, Finland, France, Germany, Japan, Spain, Switzerland, United Kingdom, United States
Busted Butte	Bedded tuff, Calico Hills Formation; Yucca Mountain, Nevada, USA; 100 m.	USDOE; operating since 1998.	

Table 2.8c: Site -specific URLs in NEA Member countries

URL	Host rock, location, depth	Organisation, remarks	Other NEA countries co-operating in research
ONKALO	Granite (tonalite); Finland; 500m	Posiva; authorised in 2001, construction to begin in 2003.	
Meuse/Haute Marne	Shale (indurated clays), Callovo-Oxfordian Argilites; France; 450-500 m.	ANDRA; potential repository site, Shaft construction began 2000.	Japan
Gorleben	Salt dome; Lower Saxony, Germany; several depths below 900 m.	BfS, DBE; shafts constructed 1985-1990. Exploratory work for potential repository site suspended for 3-10 years by governmental moratorium on October 1, 2000.	
Konrad	Limestone covered with shale; Germany; 800 m.	BfS, DBE; galleries in former iron mine, was licensed as a LILW repository on June 5, 2002, but has not been commissioned to begin storage yet.	
Morsleben	Salt dome; Germany; several depths below 525 m.	BfS, DBE; former salt and potash mine, repository for LLW and ILW since 1981. Disposal operation was stopped in 1998, at present, efforts are focussing on site decommissioning and final closure.	
Pécs (Mecsek Mountain)	Indurated clay, Boda Claystone Formation; Hungary; 100 m.	PURAM; former uranium mine, operated 1995-1999.	
Waste Isolation Pilot Plant (WIPP)	Salt (bedded), Salado Formation; Carlsbad, New Mexico, USA; 655 m.	USDOE; operating since 1982, licensed transuranic (TRU) waste repository since 1999.	Belgium, Canada, France, Germany, Japan, Sweden, United Kingdom
Exploratory Studies Facility (ESF)	Welded tuff, Calico Hills Formation; Yucca Mountain, Nevada, USA; 300 m	USDOE; *in situ* testing began in 1996; construction of an exploratory side tunnel completed in 1998.	

An increasing trend in recent years has been for implementing bodies in the more advanced nations to begin marketing their expertise to newer programs through the establishment of specific consulting divisions. This has happened in Sweden, the UK, Switzerland, and Belgium. The revenues, however, are generally modest compared to the costs of running a national program; thus, larger programs (e.g. France, USA) have not taken this path.

The uneven nature of the technical expertise and the funding available in different countries that are trying to develop waste management programs has led to increased, sometimes controversial, discussion on a further type of intense international cooperation. This is the concept of shared international disposal facilities, as discussed in the following section.

2.8.2 International Repositories

In earlier years, for example in the 1950s as the IAEA was formed or in the 1970s as the major International Fuel Cycle Evaluation (INFCE) project was carried through, the concept of international facilities was generally supported. There were proposals for fuel cycle centres (e.g. at Gorleben in Germany) where all of the relevant activities, including disposal, could take place and also be offered as a service to other countries. Indeed, the early reprocessing countries accepted that the residual HLW of foreign customers would be disposed of in the country providing the service (France, UK, Russia).

In the late 1970s, opposition to accepting foreign wastes grew, and further reprocessing contracts in France and the UK required return of HLW and other residues to the customer. Later, the view that radioactive wastes should be neither imported nor exported became more widely promoted, in particular by environmental organisations. This led national disposal programs that were in a sensitive siting phase to try to avoid discussions on the subject or even to introduce policies or laws forbidding import of wastes. In turn, the IAEA, which in the early 1990s had supported specific studies on the topic, also reduced its activities.

More recently, however, the subject of shared repositories has again been increasingly debated. The potential advantages of countries sharing centralised facilities for storage and disposal of spent nuclear fuel or HLW are generally recognised. They include increased global nuclear safety and security as well as improved local and regional economics. One reason for the more open discussion of these benefits is that some countries (such as Sweden and Finland) have effectively passed the sensitive siting stage and have made clear by law that they will not import wastes. A further reason is that there are increasing security concerns about spent fuel and other wastes being stored in numerous countries, often without a definite plan for their long-term disposition. The availability of shared repositories – or also simply storage facilities - could ease this situation. The third reason is the increasing realisation that many small countries with limited nuclear power programs may not have the technical and financial resources to implement costly deep disposal facilities.

What are the current positions across the globe on this question? The international bodies acknowledge the potential benefits and both the IAEA and the EC are supporting work on the concept. The IAEA has organised a working group that has produced a report on multinational repositories (IAEA 2004) and the EU, recognizing the needs of its present applicant countries, is funding a study, titled SAPIERR, on European regional repositories (Stefula and McCombie 2004). Nevertheless, some countries remain strongly opposed to international repositories (e.g. Germany, UK); some have no intention to import or export but do not dispute that this might be a sensible route for others (e.g. USA, Sweden, Finland). At another extreme, some would definitely prefer international disposal (e.g. Austria, Bulgaria, Netherlands, Slovakia, Slovenia); finally some explicitly keep both national and international options open (e.g. Switzerland, Belgium, Czech Republic).

Different approaches to developing multinational repositories or storage facilities have been proposed or tried. They can be classified as follows:

- Top-down decision by a national government: This approach implies direct support at political levels for an initiative to host a multinational repository. Proposals of this type have in the past come mainly from Russia and China. In fact, Russia formerly did accept returned SNF from the surrounding countries, mainly for security reasons, and has expressed a will at the political level to resume this practice.

- Private, commercial enterprise: In the nuclear area, there are examples of private initiatives being able to respond more flexibly to the requirements of partners and thus being able to site potentially controversial facilities. In the international arena, the most recent initiatives are the Non-Proliferation Trust (NPT) proposal and the Pangea Project. Both had solid technical and economic concepts behind them, but neither has led to success, primarily because the necessary top-down support was lacking.

- Bottom-up self-help group: This is based on the concept of countries with a common problem that they cannot easily solve alone coming together to explore common solutions. The Arius Association, founded in 2002 (see next Chapter), is an example of this type of self-help organisation. More recently still, a number of small Central European countries have begun to discuss the option of jointly developing shared repositories.

- Supra-national decisions and organisation: This terminology is applied to the case where the initiative is taken by a special body that organises or coordinates a number of nations in a specific area. There are already such entities in the nuclear field, the prime examples being the IAEA, the EU and the NEA. This does not imply that these organizations have powers over their member states. In fact, they are creatures of the member states, and cannot go beyond the will of the members, especially the more powerful.

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3 INTERNATIONAL ORGANISATIONS AND INITIATIVES

3.1 The Role of International organisations

As emphasised in this report, international co-operation in the field of nuclear matters in general, and radioactive waste management specifically, is particularly intensive. The coordination is fostered by a number of international organisations providing multiple fora for information exchange; the structure, methods of operation and objectives of the principal bodies are described in this chapter. Much of the information given resulted from extracting the relevant waste management data from the comprehensive web sites of the organisations. The organisations with widest membership are the IAEA and the NEA. These have complementary roles, but with different emphasis. For example, the IAEA deals with security and safeguards and with technical assistance to developing countries; the NEA, with about 80% of the world's nuclear capacity, represents the technical expertise of the more developed economies.

3.1.1 IAEA - International Atomic Energy Agency (IAEA)

www.iaea.org

Background

The IAEA is the world's primary centre of cooperation in the nuclear field. It was set up in 1957 within the United Nations family, as result of the "Atoms for Peace" initiative proposed in 1953 by President Eisenhower to the UN. The Agency works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies. The IAEA has currently 137 members states, including many that do not use nuclear power.

The IAEA Secretariat is headquartered in Vienna, Austria. Operational liaison and regional offices are located in Geneva, New York, Toronto, and Tokyo. The IAEA runs or supports research centres and scientific laboratories in Vienna and Seibersdorf in Austria, in Monaco; and in Trieste, Italy.

Three main issues are the concern of the IAEA:

- Safety and Security
- Science and Technology
- Safeguards and Verification

Departments Dealing with Radioactive Waste

A stated objective of the IAEA is to have state-of-the-art nuclear fuel cycle and waste management strategies adopted in Member States. To this end it facilitates the planning and implementation of safe, sustainable, cost efficient and environmentally sound nuclear fuel cycle and management.

In order to separate transparently the IAEA roles in the promotion and the regulation of nuclear technologies, its activities in each area are carried out in different Departments. Thus, different aspects of radioactive waste management are dealt with in the Department of Nuclear Safety and Security and the Department of Nuclear Energy.

Department of Nuclear Safety and Security

Within the Department of Nuclear Safety and Security (DNSS), the Radiation and Waste Safety Division (NSRW), is concerned with radiation safety in the application of nuclear technologies. This includes, among other topics, the safe management of radioactive wastes.

DNSS is also responsible for issuing international radiation and waste safety standards. Assisting in this task is the Waste Safety Standards Committee (WASSC), a standing body of senior regulatory officials with technical expertise in radioactive waste safety. WASSC provides advice to the Secretariat on the overall program on regulatory aspects of radioactive waste safety and has the primary role in the development and revision of the Agency's radioactive waste safety standards.

The primary functions of WASSC are:

- To recommend the terms of reference of all standards in the Agency's radioactive waste safety standards program and of the groups involved in the development and revision of those standards

- To agree on the texts of Safety Fundamentals and Safety Requirements to be submitted to the Board of Governors for approval and of Safety Guides to be issued under the authority of the Director General

- To identify and advise on any necessary activities in support of the radioactive waste safety program

Within the area Radioactive Waste Management, important published Safety Standards are "Predisposal Management of Radioactive Waste, Including Decommissioning" (2000), and the recently issued "Predisposal Management of High Level Radioactive Waste" (2003). A new Safety Standard "Storage of Radioactive Waste" exists in draft format.

Within the area Waste Treatment and Disposal Facilities, important published Safety Standards are "Near Surface Disposal of Radioactive Waste" (1999) and "Siting of Geological Disposal Facilities" (1994). A new Safety Standard "Geological Disposal of Radioactive Waste" exists in draft format.

The IAEA Safety Standards have no legal jurisdiction. In practice however, the Member Countries usually comply with their recommendations.

Department of Nuclear Energy

Within the Department of Nuclear Energy, the Division of Nuclear Fuel Cycle and Waste Technology is responsible for formulating and implementing the Agency's waste management policy. Within the Division, the Waste Technology Section was established to promote the use of sustainable radioactive waste management strategies and technologies in Member States, particularly in the areas of the disposal of SNF, high level and long-lived waste, and decommissioning.

The Waste Technology Section is responsible for implementing activities under the Agency's subprograms:

- Technologies for Disposable Radioactive Waste Management, and
- Radioactive Waste Management Information

One of the objectives of the Technologies for Disposable Radioactive Waste Management subprogram is to build confidence in technologies for geological disposal of high-level waste. This includes coordinating an IAEA "Network of Centres of Excellence" devoted to the "Training In and Demonstration Of Waste Disposal Technologies in Underground Research Facilities" under which nationally developed Underground Research Facilities and associated laboratories are being offered for use by other nations, under the auspices of the IAEA.

Network Members are owners of facilities in Member States which can be recognized as Centres of Excellence and have offered their facilities to host training and demonstration activities as part of the Network. At present, Network Members are :

- Belgium with the HADES URF of Mol, built in the Boom plastic clay strata,
- Canada with the Underground Research Laboratory (URL) of Lac-du-Bonnet, Manitoba, built in a granitic batholith of the Canadian Shield,
- Lawrence Berkeley National Laboratory (USA)
- Switzerland with the Grimsel Test Site (GTS) built in granite and the Mont-Terri URL built in consolidated claystone,
- The University of Wales - Geoenvironmental Research Centre - Cardiff (UK),
- USA with the WIPP facility near Carlsbad, New Mexico, built in bedded salt and the Yucca Mountain facility built in volcanic tuffs.

Joint Convention

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention) aims to achieve and maintain a high level of safety worldwide. The mechanism for achieving this is through the “peer review” of national programs for spent fuel and radioactive waste management.

The Joint Convention applies to spent fuel and radioactive waste resulting from civilian nuclear reactors and applications, and to spent fuel and radioactive waste from military or defence programs, if such materials are transferred permanently to exclusively civilian programs. The Convention also applies to planned and controlled releases into the environment of liquid or gaseous radioactive materials from regulated nuclear facilities.

The 33 Contracting Parties to date are: Argentina, Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Japan, Republic of Korea, Latvia, Luxembourg, Morocco, Netherlands, Norway, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom, and United States.

The obligations of the Contracting Parties with respect to the safety of spent fuel and radioactive waste management are based to a large extent on the principles contained in the IAEA Safety Fundamentals document "The Principles of Radioactive Waste Management", published in 1995. They include, in particular, the obligation to establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management and the obligation to ensure that individuals, society and the environment are adequately protected against radiological and other hazards, *inter alia*, by appropriate siting, design and construction of facilities and by making provisions for ensuring the safety of facilities both during their operation and after their closure. The Convention imposes obligations on Contracting Parties in relation to the transboundary movement of spent fuel and radioactive waste based on the concepts contained in the IAEA Code of Practice on the International Transboundary Movement of Radioactive Waste. Also, Contracting Parties have the obligation to take appropriate steps to ensure that disused sealed sources are managed safely.

In November 2003 the first Review Meeting of the Joint Convention was held in Vienna. The meeting concluded that the Joint Convention process had already contributed significantly to achieving the objectives of the Convention. Firstly, as a result of being prompted by the forthcoming Review Meeting, several Contracting Parties had made improvements to the management of spent fuel or radioactive waste in the period leading up to the Meeting, secondly, others acknowledged that the process of preparing the National Report had been beneficial since it had identified needs and deficiencies in the national arrangements for radioactive waste management and thirdly, still others had identified improvements for the future and volunteered to report on progress in their implementation at the next review meeting.

3.1.2 OECD/NEA - The Nuclear Energy Agency of the Organisation for Economic Cooperation and Development

www.nea.fr

The Nuclear Energy Agency (NEA) assists member countries in the area of radioactive waste management, developing safe management and disposal strategies for spent fuel, long-lived waste, and waste from the decommissioning of nuclear facilities.

The NEA objectives in this area are

- to ensure the exchange of information and experience and increase understanding on management of long-lived waste, spent fuel and decommissioning waste;
- to elaborate waste management strategies, including regulatory approaches;
- to increase scientific and technical knowledge for the management of radioactive waste;
- to enhance co-operation with non-member countries with a view to promoting safe waste management practices and addressing current waste management concerns.

The work program in the area of radioactive waste management is supervised by the Radioactive Waste Management Committee.

Radioactive Waste Management Committee

The Radioactive Waste Management Committee (RWMC) is an international committee made up of senior representatives from regulatory authorities, radioactive waste management agencies and research and development institutions. The main tasks of the RWMC are:

- to provide a forum for the exchange of information and experience on waste management policies and practices in NEA Member countries;
- to develop a common understanding of the basic issues involved, and to promote the adoption of common philosophies of approach;
- to keep under review the state-of-the-art in the field of radioactive waste management at the technical and scientific level;
- to contribute to the dissemination of information in this field through the organization of specialist meetings and publication of technical reports and consensus statements summarizing the results of joint activities;

- to offer, upon request, a framework for the conduct of international peer review of national activities in the field of radioactive waste management, such as R&D programs, safety assessments, specific regulations, etc.

In the fulfilment of its responsibilities, the Radioactive Waste Management Committee works in close co-operation with the Committee on Radiation Protection and Public Health (CRPPH), the Committee on Nuclear Regulatory Activities (CNRA) and the Committee on the Safety of Nuclear Installations (CSNI) and with other NEA Committees as appropriate. The Regulators in the RWMC meet regularly in the Regulators' Forum (RWMC-RF).

Work Program

The main focus of the NEA waste management program is on the strategies for the disposal of long-lived radioactive waste, mostly spent fuel and high-level waste from fuel reprocessing, and on the assessment of long-term safety and the evaluation of geological sites potentially suitable for the construction of underground disposal facilities.

In the area of radioactive waste management RWMC is currently assisted by three working parties:

- the Forum on Stakeholder Confidence (FSC)
- the Integration Group for the Safety Case (IGSC)
- the Working Party on Management of Materials from Decommissioning and Dismantling (WPDD)

The RWMC reviews progress in the implementation of waste disposal strategies and policies. Emphasis is placed on regulatory aspects of radioactive waste management in co-operation with the CNRA and the CRPPH. Specific studies also refer to non-technical issues such as economic matters, public information and social aspects. Peer reviews of national activities are carried out on request, sometimes collaborating with the IAEA. Reviews of this type have been carried out for national programs of Belgium, Canada, Sweden and Switzerland.

RWMC Working Parties

Forum on Stakeholder Confidence (FSC):

The Forum on Stakeholder Confidence (FSC) "facilitates the sharing of experience in addressing the societal dimension of radioactive waste management, explores means of ensuring an effective dialogue with the public, and considers ways to strengthen confidence in decision-making processes". The NEA has recognised that the times when nuclear energy institutions communicate with society only through rigid mechanisms provided by the law are over. A more complex interaction is now taking place among players at national, regional and especially at local levels, as large industrial projects are highly dependent on siting and other local considerations. Consequently the NEA tries to promote a broader, more realistic view of decision making, encompassing a range of actors in civil society.

The Forum was created under a mandate from the RWMC to share experience in achieving stakeholder confidence. The Forum also advises the RWMC on major and emerging issues in the area of public perception and stakeholder confidence related to radioactive waste management.

Since its inception the FSC has held meetings in Belgium, Canada, Finland and France. In these, a wide spectrum of stakeholders from the host country are invited to express their views on the nature of their involvement and the process by which they are involved.

Integration Group for the Safety Case (IGSC):

The IGSC focuses on developing, evaluating and communicating the "safety case" as a basis for confidence and decision-making in radioactive waste disposal. A safety case comprises the integrated technical basis, at a given stage of development, in support of the long-term safety of a waste disposal site. In particular, the IGSC addresses the following issues:

- the process of repository development for long-lived radioactive wastes
- system analysis and technological advantages;
- confidence in repository technical safety cases and their underlying methodological and scientific bases;

The IGSC is a working party of the RWMC and is made up of senior technical specialists experienced in the assembling or review of the safety case for deep geological disposal projects. The IGSC currently has 46 members from 38 organizations in 17 countries.

Working Party on Decommissioning and Dismantling (WPDD):

The WPDD brings together senior representatives of national organizations who have a broad overview of Decommissioning and Dismantling (D&D) issues through their work as regulators, implementers, R&D experts or policy makers.

The Secretary of the EC Thematic Network on Decommissioning is a member of the WPDD, and the IAEA also participates. This ensures close co-ordination with activities in these programs. Participation from civil society organizations is a common feature in WPDD activities.

The WPDD is mandated to:

- Analyse and comment on policies and strategies of D&D including:
  - financial aspects;
  - recycling/reuse and/or disposal of materials;
  - release/reuse of sites and buildings;
- Complement, at policy and regulatory levels, the technical work of the CPD (International Co-operative Program for the Exchange of Scientific and Technical Information Concerning Nuclear Installation Decommissioning Programs);
- Make experience available to other bodies;
- Facilitate communication and information exchange among WPDD members and promote open dialogue among peers in industry, regulatory authorities and R&D;
- Keep the RWMC aware of ongoing international activities and help the RWMC participate in international activities (EC, IAEA);
- Develop the link between D&D/decision making/public acceptance and confidence;
- Set up, manage and make broadly available a database of information on D&D in member countries.

Working Methods

The RWMC and its three working parties provide the overall forum for information exchange amongst the national programs. Detailed technical work is carried out by means of working groups, topical sessions, workshops or symposia, technical reviews. Working groups produce state-of-the-art reports and detailed analyses. Workshops and symposia provide opportunities for in-depth information exchange, communications and discussion of new ideas and hypotheses. The NEA publishes the proceedings of these workshops and symposia.

In the last decade the NEA has published a number of influential overview documents in addition to its technical documentation on its meetings. These include a series of three "Collective Opinions" on the safety and ethical basis for geological disposal, and also a broad overview of programs made over the last decade of the 20th century.

The NEA works in close collaboration with the International Atomic Energy Agency (IAEA). The programs of work of the two agencies are complementary. Results of these programs are made available to the international nuclear community. Many experts who attend NEA meetings also go to the IAEA. Representatives of the European Commission also participate in most NEA activities.

3.1.3 EC - European Commission

www.europa.eu.int

EURATOM Treaty

Cooperation within the European Union on all nuclear topics is organized under the Euratom Treaty. The Treaty, which established the European Atomic Energy Community, is one of the founding treaties of the European Union. The Treaty was originally drafted in the 1950s and addresses the issues in the field of nuclear power that were relevant at that time. However, the Euratom Treaty makes little or no specific mention of aspects such as the safety of radioactive waste storage or disposal facilities. This may have been because these were not major concerns at the time the Treaty was drawn up. As a result, regulatory activities in these areas have developed along national lines under the responsibility of national authorities. International organizations such as the IAEA and, to a lesser extent, the OECD/NEA have, through their efforts, resulted in a certain standardization at the qualitative level of the design, operational and maintenance aspects of these nuclear installations. Several international conventions have helped to establish a culture of best practice amongst the Member States of these organizations (which include all the EU Member States).

EU Commission Proposals

The forthcoming enlargement of the European Union, which will bring in countries with nuclear power stations, many of them several decades old, indicated a need for Community action in the nuclear sector, independent of the energy policy choices made by the Member States. A new reference framework on nuclear safety standards was judged to be necessary for the whole Community, since it would be inconceivable for the Union to monitor nuclear safety in just the new Member States but not in the rest of the enlarged Union.

To produce a Community approach to nuclear safety the Commission has proposed a package of three measures covering nuclear safety and the decommissioning of obsolete installations, the management of radioactive waste and trade in nuclear materials with Russia.

In the present context, the key Directive is on the management of radioactive waste. The current draft acknowledges geological disposal of waste as the safest method of disposal in the present state of the art. It provides that Member States should adopt national programs and commit themselves to a timetable for the disposal of radioactive waste in general and deep disposal of highly radioactive waste in particular. They are required to submit national radioactive waste management plans, including their own deadlines, to the EC by 2006. The draft Directive has met with opposition – some countries, e.g. UK, have not decided on geological disposal; many countries would have great difficulties in meeting the proposed date. Some Member States are also objecting to any new Directives being based on the original Euratom Treaty, which they regard as being promotional towards nuclear energy.

Directorates-General Dealing with Radioactive Waste

Out of the many Directorates-General (DGs) of the European Commission, there are three that are particular important for radioactive waste management:

- DG Energy and Transport (DG TREN),
- DG Joint Research Centre (DG JRC), and
- DG Research.

DG TREN

A merger of the Directorate-General for Transport and the Directorate-General for Energy on 1 January 2000 created the Directorate-General for Energy and Transport (DG TREN). DG TREN is responsible for developing and implementing European policies in the energy and transport field. DG-TREN develops Community policies in the nuclear sector with the main emphasis on establishing a regulatory framework to ensure the safety of nuclear installations in Europe and the proper management of radioactive waste. In June 2002 the Euratom Safeguards Office became part of DG TREN, putting staff numbers of DG TREN up to around 1000. The Directorate-General includes 9 Directorates, two of which deal with Euratom issues. The staffs are divided between Brussels and Luxembourg. The Division responsible for issuing Directives on the management of SNF and radioactive waste is the Division of Nuclear Energy and Nuclear Safety, belonging to the Directorate of Nuclear Safety and Safeguards.

Euratom priorities with respect to the management of radioactive waste are defined to be

- research aimed at reducing the impact of waste, in particular through the development of new technologies to reduce the hazards associated with waste by means of partitioning and transmutation techniques, as well as exploring the potential of concepts to produce less waste in nuclear energy generation; and
- research into processes for long-term storage in deep geological strata, with the networking of the activities carried out on various sites in the three main types of geological formations envisaged.

Setting up and encouraging co-operation, co-ordination and information exchange between the various bodies and organizations involved in radioactive waste management are an integral part of the Commission's activities within the Community. Close contacts are maintained with the national regulators and legislators, the national waste management organizations, the nuclear industry, international bodies and non-governmental organizations.

The Commission holds the chair of the Club of Agencies (high-level group of European national radioactive waste management organizations - see chapter 3.1.4) and the secretariat of the recently formed Forum of Radioactive Waste Regulators (an ad-hoc group of EU regulators involved in radioactive waste issues). The Commission also originally hosted the Natural Analogue Working Group (NAWG). This is an organization that was formed in order to offer an international forum for discussion of natural analogue programs, and for assessing the relevance and appreciation of natural analogues to radioactive and toxic waste disposal, see chapter 3.1.4.

DG JRC

The Joint Research Centre Directorate-General (DG JRC) is the EU's scientific and technical research laboratory and the Directorate-General of the European Commission responsible for providing scientific advice and technical know-how to support EU policies.

Within the nuclear safety and security area, DG JRC priorities include:

- nuclear safeguards and non-proliferation control techniques on behalf of the International Atomic Energy Authority (IAEA) and the European Safeguards Organization (ESO), and
- safety of existing nuclear plants and developments in the nuclear waste area.

DG JRC is one of the largest Commission DGs with a €300 million budget and has staff working in seven scientific institutes located in Geel (Belgium), Ispra (Italy), Karlsruhe (Germany), Petten (the Netherlands) and Seville (Spain).

DG JRC also supports activities like the Cluster Repository Project (CROP), which is an international project with the objective to compare and evaluate results from investigations of engineered barriers in underground research laboratories. The aim of CROP is to create a forum for exchange of information on repository design, construction and operation with the purpose of optimising scientific networking among key experts in the involved countries.

DG Research

The mission of the Directorate-General Research can be summarized as follows:

- to develop the European Union's policy in the field of research and technological development and thereby contribute to the international competitiveness of European industry;

- to coordinate European research activities with those carried out at the level of the Member States;

- to support the Union's policies in other fields such as environment, health, energy, regional development etc; and

- to promote a better understanding of the role of science in modern societies and stimulate a public debate about research-related issues at European level.

One of the main instruments used for the implementation of this policy is the multi-annual Framework Program, which helps to organize and financially support cooperation between universities, research centres and industries - including small and medium sized enterprises. Currently in progress is FP6, adopted on 3 June 2002 by the Council of Ministers and European Parliament; it is open to public and private entities for four years from the end of 2002 through to 2006.

The Division responsible for the Euratom area of the Framework Programs is the Division on Nuclear Fission and Radioprotection, belonging to the Directorate of Energy.

Sixth Framework Program (FP6)

The priorities covered by FP6 include an enormously wide range of scientific fields. The overall budget for FP6 is €17,500 million, which represents 3.4% of the EU's total budget in 2002. Out of the €17,500 million, €1,230 million has been earmarked for Euratom activities and out of these, €90 million has been set aside for research on the management of radioactive waste. The budget for DG JRC direct action in FP6 is €1,050 million out of which €330 million covers programs in the nuclear field.

Emphasis in the waste management part of FP6 is on permanent deep disposal as a solution for the long-term management of radioactive waste. It is acknowledged that new technologies for the treatment of radioactive waste have not yet resulted in an alternative to geological disposal but they are viewed as an important complementary strategy. Therefore, at the same time as developing deep disposal sites, the development of new technologies is encouraged in FP6, "in order to offer future generations the possibility of having more effective methods for treating waste, such as "partitioning and transmutation" technology for example". Over the years there has been a growing awareness that socio-political aspects need to be considered when developing a system for the disposal of nuclear waste. Accordingly, a significant portion of FP6 will be devoted to research regarding development and evaluation of processes that properly address public concerns on waste disposal.

In particular, a separate research program will be established with the objectives of better understanding what influences public acceptance and of developing guidelines for the improved governance of geological waste disposal. The scope of this research program includes:

- Critical analysis, based on case studies in Member States, on current and past decision-making processes on waste management and disposal
- Co-operation and dialogue with different social actors
- Develop guidance on better governance processes, taking account of national differences (e.g., culture, history, legal and administrative regimes)

Broad participation from the human and natural sciences and the main stakeholders (e.g. waste management organizations, regulators, local authorities, public interest groups, non-governmental organizations, etc) will be required to achieve the objectives.

3.1.4 Others

EDRAM - Environmentally Safe Disposal of Radioactive Materials

www.edram.org

The International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM) was created with the aim of sharing research results among members while attempting to broaden the field of research on nuclear waste.

EDRAM members are the organizations responsible for radioactive waste management in currently 11 countries:

- Belgium: ONDRAF/NIRAS
- Canada: Ontario Power Generation
- Finland: POSIVA
- France: ANDRA
- Germany: BfS, DBE
- Japan: NUMO
- Spain: ENRESA
- Sweden: SKB
- Switzerland: NAGRA
- United Kingdom: Nirex
- United States: OCRWM

EDRAM has documented the common views of members on some key issues and has sponsored some member reports to be found on its web site.

WNA - World Nuclear Association

www.world-nuclear.org

The World Nuclear Association is a global industrial organization that seeks to promote the peaceful worldwide use of nuclear power as a sustainable energy resource for the coming centuries. Specifically, the WNA is concerned with nuclear power generation and all aspects of the nuclear fuel cycle, including mining, conversion, enrichment, fuel fabrication, plant manufacture, transport, and the safe disposition of spent fuel.

Ongoing WNA working groups, consisting of Institutional Members and supported by the London-based Secretariat, share information and develop analysis on a range of technical, trade and environmental matters. One of the working groups is on waste management and decommissioning.

Club of Agencies

The Group of Agencies is an alliance of the major national radioactive waste disposal organisations of the European Union, with the European Commission holding the chair.

- The members of the Club of Agencies are:
- Belgium: ONDRAF/NIRAS
- Finland: Posiva
- France: ANDRA
- Germany: BfS
- Italy: ENEA
- The Netherlands: COVRA
- Spain: ENRESA
- Sweden: SKB
- United Kingdom: Nirex

The Club meets about twice each year, providing an opportunity for the members to discuss the national programs.

Natural Analogue Working Group

www.natural-analogues.com

Owing to the considerable upsurge of interest on the topic of natural analogues, a group of individuals working for or in national waste disposal programs, took the initiative of establishing, in June 1985, NAWG, the Natural Analogue Working Group (originally under the auspice of the European Commission).

This was carried out to offer an international forum for:

- Discussion of natural analogue programs.
- Assessing the relevance and appreciation of natural analogues to radioactive and toxic waste disposal.

The current members of NAWG are:

- Switzerland: Nagra
- Belgium: ONDRAF/NIRAS
- Czech Republic: NRI-REZ
- Finland: GSF
- France: CEA
- Germany: FZK
- Japan: JNC
- Korea: KAERI
- Slovakia: Slovak Geological Survey
- South Africa: AEC
- Spain: ENRESA
- Sweden: CONTERRA
- Taiwan: ERL/ITRI
- UK: EA
- USA: CNWRA

Advances made since the formation of NAWG are:

- Studying natural analogues has greatly increased understanding of relevant processes and capability to describe and model them.
- The larger, multi-objective analogue studies are a very cost effective way of training performance assessment groups on real, complex systems.
- The application of analogues in broadening public perception of the natural context of waste disposal is under development.
- An increased awareness of the potential for studying natural analogues of chemotoxic waste.

Cassiopee

Cassiopee is a commission assembled by some of the major waste management organizations in Western Europe It was established in 1993 with a view to assisting countries in Eastern Europe in developing radioactive waste management systems.

The members of Cassiopee are:

- Belgium: ONDRAF/NIRAS
- France: ANDRA
- Germany: DBE
- The Netherlands: COVRA
- Spain: ENRESA
- United Kingdom: Nirex

The creation of Cassiopee facilitates the sharing of knowledge and experience between Eastern European countries and their counterparts in Western Europe. This was a major step in radioactive waste management cooperation before the enlargement of the European Union.

Arius

www.arius-world.org

The Association for Regional and International Underground Storage (ARIUS) was set up in early 2002 as a non-commercial body to promote the concept of regional and international facilities for storage and disposal of all types of long-lived nuclear wastes. A key objective is to explore ways of providing shared storage and disposal facilities for smaller users. Membership is open and comprises countries with small nuclear programs as well as industrial organizations with relevant interests. Arius is initially focusing on the feasibility of regional repositories in Europe.

The founding organizational members of Arius are:

- Belgium: ONDRAF Waste Agency
- Bulgaria: Kozloduy Nuclear Power Plant
- Hungary: PURAM Waste Agency
- Italy: ENEA

- Japan: Obayashi Corporation
- Switzerland: Colenco Power Engineering

At the end of April 2003, ARIUS and Decom of Slovakia initiated the Pilot Initiative for European Regional Repositories (SAPIERR). This initiative has been welcomed by potential participants in numerous EU member states and associated countries. The project is a timely initiative in the light of the Directive issued by the European Commission on implementation of waste repositories which implies that regional facilities can help small countries satisfy requirements.

SAPIERR has recently received European Commission approval and will help the EC grapple with the regional repository issue. It will allow potential options for regional collaboration and for regional repositories to be identified, though it will not extend to site identification.

4 DATA SOURCES GIVING INTERNATIONAL OVERVIEWS

This Chapter contains a selection of useful references, each of which includes an overview of relevant issues covering waste management programs in a number of countries. The key documents of this type commonly come from the international organisations (in particular IAEA, NEA and EC), but various other organisations have also produced overviews. The document list is structured according to topics addressed. For the individual country data sheets in the Appendices the primary source of material has been the Joint Convention Report of the relevant country together with IAEA Tec-doc-1323 referred to below. Other documents have been used to fill gaps in the data, as has information derived from personal contacts.

This information in the documents listed in section 4.1 is complemented by a list of useful internet sites. This world-wide web is today the most effective method of accessing such data for many persons. The web sites given are those that cover a number of countries. Of course each country also has a number of national web-sites with more extensive data. The most important sites are listed in the tables of the Appendix.

Finally, a vast amount of information is produced in the proceedings of the numerous Conferences and Workshops held in the area of radioactive waste management. The concluding section therefore identifies the major recurring Conferences in this area.

4.1 Reference Overview Documents

The following list notes overview documents in different categories. These documents form a useful complement to the references given in Section 2.3

General

IAEA (1989): Safety Principles and Technical Criteria for the Underground Disposal of High Level Radioactive Wastes. SS 99. 1989.

IAEA (1995): The Principles of Radioactive Waste Management. Safety Fundamentals 111,1995.

IAEA (1995): Establishing a National System for Radioactive Waste Management. N° 111 - S-1, 1995.

IAEA (2002): Institutional framework for long term management of high level waste and/or spent nuclear fuel, IAEA-TECDOC-1323

IAEA (2003): Radioactive Waste Management Profiles—Compilation of Data from the Waste Management Database. No. 5. Vienna: IAEA. April.

NEA, (2001): Nuclear Waste Bulletin, Update on Waste Management Policies and

Programmes, No. 14 – 2000 Edition, 2001.

EC (1999/2000): General Overview of Existing and Future Requirements for Decommissioning Nuclear Facilities, Report EUR 19155

EC (1998) Radioactive Waste Management in the European Union A 24-page booklet based on the Fourth Situation Report, published in September 1998. All enquiries regarding availability should be addressed to tren-nuclear-safety@cec.eu.int

EC (1999). Radioactive Waste Management in the Central and Eastern European Countries, Report EUR 19154,

EDRAM website. The management of radioactive waste: A description of ten countries, Rolf Lidskog & Ann-Catrin Andersson

EURELECTRIC (2001): Nuclear Power Plants' Radwaste in Perspective Rep: 2001-2110-0008 December 2001, Union of the Electricity Industry, 66 Boulevard de l'Impératrice, BE-1000 Brussels

Nuclear Energy Agency (NEA) (1999): Geological Disposal of Radioactive Waste: Review of Developments in the Last Decade. NEA/RWM(99)6. Paris: Organization for Economic Cooperation and Development. October.

Nuclear Energy Agency (NEA) (1997) Regulating the long-term safety of radioactive waste disposal. In: Proceedings of Conference in Cordoba, Spain. January. Madrid: Consejo de Seguridad Nuclear. 337 pp.

NEAA/OECD: Each year at the annual meeting of the RWMC, all NEA countries give an update, which is available from country representatives.

KASAM (Swedish National Council for Nuclear Waste) (1998): Nuclear Waste: State of the Art Reports. Swedish Official Report Series. Vol. 68. Stockholm: Swedish National Council for Nuclear Waste.

McCombie C. (1997): Nuclear waste management worldwide; 1997 American Institute of Physics, Physics Today; June 1997, pp56-62

Regulatory

NEA (1997): Joint CNRA/CRPPH/RWMC Workshop, Regulating The Long-Term Safety Of Radioactive Waste Disposal Proceedings of an NEA International Workshop, Cordoba, Spain 20-23 January 1997

NEA (2000): Regulatory Reviews of Assessments of Deep Geologic Repositories - Lessons Learnt, OECD

NEA (2003): The regulatory control of radioactive waste management in NEA member countries

EC (1990): Objectives, standards and criteria for radioactive waste disposal in the European Community (Euradwaste series No 1), 1990 S. Schaller (eds.)Orlowski & K. H.

G.D. Burholt and A. Martin (1988): The Regulatory Framework for Storage and Disposal of Radioactive Waste in the Member States of the European Community.

Storage

Bunn et al (2001): Interim Storage of Spent Nuclear Fuel: A Safe, Flexible, and Cost-Effective Near-Term Approach to Spent Fuel Management (Cambridge, MA: Managing the Atom Project, Harvard University, and Project on Socio-technics of Nuclear Energy, University of Tokyo, 2001).

K. Fukuda, W. Danker, J.S. Lee, A. Bonne, M.J. Crijns (2003): IAEA overview of global spent fuel storage in Storage of Spent Fuel From Power Reactors, 2003 Conference, IAEA-CSP-20, IAEA, Vienna, 2003

IAEA (1999): Survey of wet and dry spent fuel storage IAEA-TECDOC-1100, 1999

Fairlie, Ian (2000): Dry Storage of Spent Nuclear Fuel: The Safer Alternative to Reprocessing, Report to Greenpeace International In Response to Cogema Dossiers to the La Hague Public Inquiry, May 2000

Siting and R&D

IAEA (1994) Siting of Geological Disposal Facilities: A Safety Guide. No 111 G-4.1,.

Witherspoon, P.A., Bodvarsson, G.S. (2001): Geological Challenges in Radioactive Waste Isolation, Third Worldwide Review. Ernest Orlando Lawrence Berkeley National Laboratory, University of California, California. December 2002.

Kickmaier, W., and I. McKinley, (1997): A review of research carried out in European rock laboratories. Nuclear Engineering and Design. Vol. 176. Pp. 75-81.

McCombie, C., and W. Kickmaier, (1999): Underground research laboratories: Their roles in demonstrating repository concepts and communicating with the public. In: Proceedings of Euradwaste 1999, Luxembourg, November 15-18. EUR 19143. Pp. 274-281.

Costs and Financing

EC (1999): Schemes for Financing Radioactive Waste Storage and Disposal, EUR 18185, 1999

EC (1999): Schemes for financing radioactive waste storage and disposal (annex covering

Central and East European Countries and workshop held 22

NEA/OECD (1994): The Economics of the Nuclear Fuel Cycle

COVRA (1996): Comparative Study of the Costs of Radioactive Waste in Europe.

Public Involvement

NEA (2003): Public Information, Consultation and Involvement in Radioactive Waste Management, An International Overview of Approaches and Experiences

NEA (2000): Stakeholder Confidence and Radioactive Waste Disposal. Workshop Proceedings, Paris France, 28-31 August 2000.

European Union (EU) (1999): Eurobarometer 50.0. Europeans and Radioactive Waste. Directorate General Education and Culture. Center for the Citizen. Public Opinion Analysis. Brussels. January 29.

Richardson, P.J., (1998): A review of benefits offered to volunteer communities for siting nuclear waste facilities. Stockholm: Swedish National Co-ordinator for Nuclear Waste Disposal (M 1996:C) [on-line]. Available at: http://www.radgiv-karnavf.gov.se/publikat/incitame.htm.

4.2 Useful web sites

The following web sites provide useful information that can complement the data on the international sites mentioned in Chapter 3 and the country-specific sites noted in the appendices.

http://www.radwaste.org
- provides numerous links to other web pages with radioactive waste information

http://www.radwaste.org/profile.htm
- contains numerous links to national and international organisations

http://www-newmdb.iaea.org/
- country profiles from the IAEA

http://www-rasanet.iaea.org/conventions/waste-jointconvention.htm#reports
- contains links to all of the national Joint Convention Reports

http://www.nea.fr/html/rwm/bulletin/
- gives updates on NEA country programs in 1997, 1998, 2000 and 2001

http://www.nti.org/e_research/profiles/
- emphasis on weapons of wass destruction; 25 countries discussed

http://www.enviros.com/vrepository/not_subscribed/country/netherlands/index.cfm
- world wide information; some is accessible only for commercial users

http://www.ceip.org/files/nonprolif/default.asp
- concentration on non-proliferation; 7 countries covered

http://www.nucleartourist.com/world/w-plant.htm
- contains information and illustrations on nuclear power use in all countries

4.3 Major Conferences

Recurring Conferences

HLRWM International High-Level Radioactive Waste Management Conference: held biannually in Las Vegas; the 10th Conference took place in 2003;

Waste Management Tucson: major Annual Conference covering all waste management; the 30th Conference WM'04 will be held next year. Theme: Global Accomplishments in Environmental and Radioactive Waste Management: Cost Effectiveness, Risk Reduction and Technology Implementation; http://www.wmsym.org/

ICEM International Conference on Radioactive Waste Management and Environmental Remediation: Biannual Conference: the 9th Conference was held 2003 in Oxford, with the theme “Progress Through Cooperation”

DisTec Disposal Technologies and Concepts: annual event; the next conference is in Berlin in April 2004; www.DisTec2004.com

Spectrum: annual event; the next conference on Closure of Nuclear facilities will be in Atlanta in August 2004

Global: Biannual series of Conferences; the last meetings were September 2001 in Paris, France and November 2003 in Atlanta, USA

MRS International Symposia on Waste Management: The Materials Research Society holds annual conferences; every third year these are outside the USA and of a general nature covering all scientific aspects of waste management. The 2000 symposium was in Sydney Australia, 2003 in Kalmar, Sweden.

Euradwaste ’04: Conference of the Commission of the European Communities, Radioactive Waste Management and Disposal: The next conference in Luxembourg in May 2004 will provide an overview of all EC activities in the field including policy, strategic and socio-political aspects

Major Recent Conferences

IAEA International Conference on Geological Repositories: Political and Technical Progress, Stockholm, December 2003

IAEA Vienna 2002: International Conference on Issues and Trends in Radioactive Waste Management, December 2002

IAEA Cordoba 2000: Safety of Radioactive Waste Management. STI/PUB/1094, 442 pp.; 1 figures; 2000, ISBN 92-0-101700-6,

IAEA Vienna 1998: Topical Issues in Nuclear, Radiation and Radioactive Waste Safety. STI/PUB/1044, 381 pp.; 27 figures; 1999, ISBN 92-0-101399-X

IAEA 1997 Nuclear Fuel Cycle and Reactor Strategies: Adjusting to New Realities; STI/PUB/1026, 311 pp.; 45 figures; 1998, ISBN 92-0-103797-X, English. 70.00 Euro .

5 LIST OF ACRONYMS

AEC	Atomic Energy Corporation, South Africa
AECL	Atom Energy of Canada Ltd.
AGNEB	Interdepartmental Working Group on Radioactive Waste Management
AkEnd	Arbeitskreis Auswahlverfahren Endlagerstandorte, Germany
ANDRA	National Agency for Radioactive Waste Management, France
ARAO	Agency for Radwaste Management, Slovenia
ARIUS	Association for Regional and International Underground Storage, Switzerland
BAG	Federal Office of Health, Switzerland
BfS	Federal Office for Radiation Protection, Germany
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany
BNFL	British Nuclear Fuel Limited
BRWM	Board on Radioactive Waste Management, US National Research Council
CANDU	Canadian Deterium Unranium Reactor; a type of heavy water reactor.
CEA	Commissariat de l'Energie Atomique, France
CLAB	Swedish central storage facility
CNE	National Commission of Evaluation, France
CNRA	Committee of Nuclear Regulatory Activity, NEA
CNSC	Canadian Nuclear Safety Commission
CNWRA	Center for Nuclear Waste Regulatory Analysis, USA
COGEMA	National French Waste Management Company
COVRA	Central Organisation for Radioactive Waste, the Netherlands
CORWM	Committee on Radioactive Waste Management, UK
CRPPH	Committee of Radiation protection and Public health, NEA
CSNI	Committee on Safe Nuclear Installations, NEA
D&D	Decommissioning and Dismantling
DBE	German company for construction and operation of repositories
DG-TREN	Directorate General Energy and Transport
DG-JRC	Directorate General Joint Research Center
DNSS	Department of Nuclear Safety and Security, IAEA
DSIN	Direction of Safety of Nuclear Plants, France
EA	Environment Agency, UK
EC	European Commission
EDRAM	Environmentally Safe Disposal of Radioactive Materials
EEG	Environmental Evaluation Group, USA
EKRA	Regulatory Control of Radioactive Waste Management, Switzerland (now disbanded)
ENEA	Italian National Agency for New Technology Energy and Environment
ENRESA	National Spanish Waste Management Company

EPA	Environmental Protection Agency, USA
ERL	Energy and Resources Laboratories, Taiwan
EPR	Extended producer Responsibility
FBR	Fast Breeder Reactor
FP6	Sixth Framework Programme, EC
FSC	Forum for Stakeholder Confidence
FZK	Forschungszentrum Karlsruhe, Germany
GCR	Gas Cooled Reactor
GNW	Co-operative for waste management, Wellenberg, Switzerland
GSF	National Research Centre for Environmental Health
GSF	Geological Survey of Finland
GTS	Grimsel Test Site, Switzerland
HSE	Health and Safety Executive, UK
HSK	Swiss Nuclear Inspectorate
HLW	High Level Waste
IAEA	International Atomic Energy Agency, Vienna, Austria
IGSC	Integration Group of Safety Case, NEA
ILW	Intermediate Level Waste
INFCE	International Fuel Cycle Evaluation
JNC	Japan Nuclear Cycle Development Institute
IPSN	Institute for Protection and Nuclear Safety, France
ISFSI	Independent spent fuel storage installations
ITRI	Industrial Technology Research Institute of Taiwan
KAERI	Korean Atomic Energy Research Institute
KASAM	Swedish National Council for Nuclear Waste
KNE	Commission on Nuclear Waste Management, Switzerland
KSA	Federal Nuclear Safety Commission, Switzerland
KW/h	Kilowatt hour
LILW-SL	Low - and intermediate level radioactive waste-short lived
LILW-LL	Low - and intermediate level radioactive waste-long lived.
LLW	Low Level Waste
LWR	Light Water Reactor
MA	Mining Authorities, Germany
MOX	Mixed Oxide (uranium dioxide and plutonium dioxide) Fuel
MWe	Megawatt Electric
ONDRAF	National Agency for Waste Management, Belgium
NAGRA	Swiss Co-operative for radioactive waste disposal
NAWG	Natural Analogue Working Group, EC
NEA	Nuclear Energy Agency, Paris
NIREX	United Kingdom Nirex Limited
NPP	Nuclear Power Plant
NRC	National Research Council, USA
NSRW	Radiation and Safety Division, IAEA

NWMO	Nuclear Waste Management Organisation, Japan
NWMO	Nuclear Waste Management Organisation, Canada
NWPA	Nuclear Waste Policy Act, USA
NWTRB	Nuclear Waste Technical Review Board, USA
OCRWM	Office of Civilian Radioactive Waste Management, USA
OECD	Organisation For Economic Cooperation and Development, France
PHWR	Pressurized Heavy Water Reactor
PNTL	Pacific Nuclear Transport Limited, Company owned by BNFL
POSIVA	Posiva Oy Finland
PURAM	Public Agency for Radioactive Waste Management, Hungary
RSK	Reactor-Safety Commission, Germany
R&D	Research and Development
RWMAC	Radioactive Waste Management Advisory Committee, UK
RWMC	Radioactive Waste Management Committee of NEA, France
SAPIERR	Support Action: Pilot Initiative for European Regional Repositories, EC
SEPA	Scottish Environment Protection Agency
SFR	LILW-Repository in Sweden
SNF	Spent Nuclear Fuel
SNHGS	Swiss hydrogeological and geological survey
SGS	Swedish State geological survey
SKB	Swedish Nuclear Fuel and Waste Management Company
SKI	Swedish Nuclear Power Inspectorate
SOGIN	Italian Waste Management Organisation
SSI	Swedish Radiation Protection Institute
SSK	Radiation Protection Commission, Sweden
STUK	Finnish Centre for Radiation and Nuclear Safety
TRU	Transuranic waste (contains elements having an atomic number greater than 92)
TÜV	Technical Inspection Association, Germany
URL	Underground Research Laboratory
USC	United State Congress
USDOE	United States Department of Energy
USNRC	United States Nuclear Regulatory Commission
VLJ	LILW Repository in Finland
VLLW-SL	Very Low Level Waste-short-lived
VLLW-LL	Very Low Level Waste-long-lived
VVER	Russian Pressurised Light Water Reactor
WASSC	Waste Safety Standard Committee, IAEA
WIPP	Waste Isolation Pilot Plant, New Mexico, USA
WNA	World Nuclear Association , UK

WPPD	Working Party on Decommissioning and Dismantling, NEA
ZWILAG	Company for Treatment and Storage of Radioactive Waste and Spent Fuel, Switzerland

Appendix

List of Countries

Argentina

Belgium

China

Czech Republic

Finland

France

Germany

Hungary

India

Italy

Japan

Korea

Mexico

Netherlands

Pakistan

Romania

Russia

Slovakia

Spain

Sweden

Switzerland

United Kingdom

United States

WASTE MANAGEMENT: ARGENTINA	
Nuclear Activities *Nuclear power program*	Argentina operates two heavy water reactors, CNA I (Siemens type) and CNE (CANDU type), with a total capacity of about 1,000 MWe. Construction of a 3rd PHWR was halted with about 80% completed. In 2003 however, the nuclear utility officially submitted their plans for completing the reactor to the Government. The two reactors represent 8% of the country's installed capacity but can account for up to 17% of the energy generated. Argentina has U-mining, milling, conversion, enrichment and fuel fabrication capabilities, and also produces heavy water.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	Argentina operates with the following main waste categories • Class B – Low Level Short Lived Disposable Waste • Class M – Intermediate Level Short Lived Disposable Waste • Class A – High Level and/or Long Lived Disposable Waste. As of 2001, CNA I has about 1,300 tonnes SNF in storage and CNE has about 1,400 tonnes. The two reactors together generate approximately 140 tonnes SNF per year and at the end of their operating lifetime, they are expected to have together produced a total of 5,200 tonnes.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	The implementing organization is the National Atomic Energy Commission (CNEA). The CNEA is a governmental organisation responsible for the strategic planning for the management of the SNF and the radioactive waste, including their final disposal. The regulation function is performed by the Nuclear Regulatory Authority (ARN). ARN is responsible for the regulation and supervision of nuclear activities in all matters related to nuclear and radiological safety, physical protection and control of the use of nuclear materials, licensing and surveillance of nuclear facilities and international safeguards. ARN is under the jurisdiction of the Office of the President. The fundamental institutional framework for radioactive waste management is stipulated in • The national Constitution (which prohibits waste import). • Nuclear Activity Law (No. 24804, 1997) • Radioactive Waste Management Regime (Law No. 25018, 1998).

WASTE MANAGEMENT: ARGENTINA	
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	The Argentine Government, through CNEA, exercises state ownership of the SNF. The decision on whether SNF is a waste to be disposed of, or a resource to be reprocessed, has been postponed. Until a decision is made (not before 2030), SNF will be stored at the plant sites. The SNF will be transferred from wet to dry storage. A deep geological repository will be necessary in any case, either for the vitrified HLW from reprocessing, or for the conditioned SNF to be disposed of directly. Hence, even though no decision has been taken, the studies for siting, location and operation of a deep geological repository will be made.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	At the CNA 1 reactor, SNF is stored in wet pools. The beginning of transfer to dry storage is planned for 2012. At the CNE reactor, SNF is stored in wet pools for at least six years before they are transferred to dry storage in concrete silos. It shall be possible to dispose of duly conditioned low and intermediate level long-lived radioactive waste in the HLW repository for which the main milestones are as follows: • 2025: Select the site for the deep geological repository. • 2030: Start the construction of the underground research laboratory at the site selected for the repository. • 2050: Start operation of the repository.
Approaches to Siting *Siting process; current status*	In 1980 the CNEA started a project to study granite bodies all over Argentina, entitled “Feasibility Study and Engineering Project – Repository for High Level Waste”. Due to lack of public acceptance however, the project was officially cancelled in 1992. In 1996, a new search for a deep geological disposal facility began. After a detailed review of regional geological literature, seven provinces were selected for further studies (stand 2001). Due to the lack of public acceptance however, geological research will be limited to national scale desk studies, assessing the existing information, and developing site selection factors or exclusion criteria such as seismicity, neotectonism, volcanisnm, and hydrogeology. Prospective host rock types include sedimentary (clay and evaporates), volcanoclastic and granites.

WASTE MANAGEMENT: ARGENTINA	
Finance and Economics *Cost estimates for disposal; financing method*	No public information available.
Public Involvement *Approaches at national, state, and community levels*	The cancellation in 1992 of the "Feasibility Study and Engineering Project – Repository for High Level Waste" is attributed directly to the lack of communication with the public. Consequently, within the new program, attention will be paid to those factors that caused the cancellation of the former studies, and effective social communication activities will be deployed. These communication activities will be emphasised in a social communication program that requires the involvement and training of a large group of scientists and technologists. It is accepted that royalties and local benefits will be required from a host community.
International Cooperation *Main international partners; major cooperative projects*	International cooperation is being considered to get experience abroad for training in site-selection and exclusion-criteria development.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.cnea.gov.ar (National Atomic Energy Commission) (In Spanish) www.enren.gov.ar (Nuclear Regulatory Authority) (In Spanish)
Additional Information	

<table>
<tr><th colspan="2">WASTE MANAGEMENT: BELGIUM</th></tr>
<tr><td>Nuclear Activities

Nuclear power program</td><td>Seven light water nuclear power reactors were put into operation in Belgium between 1975 and 1985.
The seven reactors are operated by Electrabel and supply some 58 % of the national electricity production. Their total capacity amounts to about 5,700 MWe.

The government decided in 2002 that the existing nuclear reactors will be shut down after their 40-year operating lifetime (i.e. between 2015 and 2025).</td></tr>
<tr><td>Waste Categories and Quantities

Categorisation of radioactive wastes; quantities of SNF and HLW</td><td>Belgium operates with the following main waste categories
A - Waste with low enough specific activities and short enough half-lives to be compatible with surface disposal.
This roughly corresponds to the category Very Low Level Waste (VLLW) as used in some other countries.
B - Waste that does not meet the radiological criterion for belonging to category A, but does not generate enough heat to belong to category C.
This roughly corresponds to the category Low and Intermediate Level Waste (LILW) as used in some other countries.
C - Waste that contains very high quantities of alpha and beta emitters and generates a thermal power of more than 20 W/m^3.
This roughly corresponds to the category High Level Waste (HLW) as used in some other countries.
According to US sources, about 2,480 tonnes of SNF had been discharged from the Belgian NPPs by the end of 2000

Belgium will shut down all of its seven reactors after they have reached a lifetime of 40 years. The corresponding total amount of SNF to be disposed of will be about 5,000 tonnes.

Belgium also has some vitrified HLW from reprocessing under existing contracts.

Depending on SNF management option chosen, see below, the forecasts for HLW/SNF waste production volume vary from 10,000 m^3, including overpacks, for the complete reprocessing option to some 12,500 m^3 for the direct disposal option.</td></tr>
<tr><td>Legal and Regulatory Framework

Implementing and regulatory bodies; advisory groups; main legislative instruments</td><td>The implementing organisation is the National Agency for Management of Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS).
ONDRAF/NIRAS is responsible for the management of all radioactive waste, and for the management of the funds provided by the waste generators.</td></tr>
</table>

WASTE MANAGEMENT: BELGIUM	
	The regulatory authority is the Federal Agency for Nuclear Control (FANC). which is responsible for nuclear safety and radiation protection regulations. The responsible governmental authorities, which establish policies and grant licenses, are: • Ministry of the Economy • Ministry of the Interior • Ministry of Justice The primary regulation applicable to the management of HLW and SNF is the General Radioprotection Regulation for the Protection of the Workers, the Population and the Environment (GRR-2001), issued by Royal Decree of 20 July 2001.
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	Until the mid-nineties the Belgian strategy for management of the back end of the nuclear fuel cycle was the reprocessing of spent fuel from all commercial nuclear power reactors. This has led to the reprocessing of 630 tonnes U of the SNF. In 1993 the parliament decided upon a moratorium on reprocessing while waiting for a decision regarding SNF management. The two options under consideration are: • Complete reprocessing option. o Reprocessing of all spent uranium fuel leaving mainly vitrified HLW to be disposed of. 70 tonnes of MOX fuel from the first reprocessing campaign would not be reprocessed. • Direct disposal option. o All spent uranium fuel and MOX fuel would be disposed of directly. Some HLW from the first reprocessing campaign would also need to be disposed of. Belgium is examining final disposal in a suitable geological formation as the most probable solution for long-term management of HLW and SNF. Although no decision regarding a repository site has been made, the reference design parameters for a repository are: • Capacity according to disposal option. • Host rock is Boom clay. • 240 m underground. • Engineered barriers consist of a watertight, corrosion resistant canister in a watertight, corrosion resistant tube. SNF will be stored at the two plant sites, Doel and Tihange, until it can be reprocessed or disposed of. Two different solutions have been selected for the two sites: • dry storage in metallic dual-purpose casks on the Doel site,

WASTE MANAGEMENT: BELGIUM	
	and • a centralized storage pond on the Tihange site. The Belgian government also encourages ONDRAF to follow the multinational disposal option and ONDRAF is a member of the Arius Association.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	The dry cask storage facility at the Doel site received the first cask in 1995. Metallic casks are ordered periodically to allow the transfer of spent fuel elements from the deactivation pools on the site to the dry storage facility. On the Tihange site the centralised storage pond received its operating licence in May 1997 and the first spent fuel assemblies were transferred in July the same year. Based on the present national nuclear program, all of the HLW and SNF to be managed in Belgium will have been generated by 2025. Since a long term management policy for this waste has not been established, it is difficult to provide a detailed time schedule for disposal of these wastes. In any case, the thermal output will require that the HLW and the SNF be stored for a 50 to 60 years cooling period. Belgium operates the HADES-URF High-Activity Disposal Experiment Site Underground Research Facility (Boom clay) at 230 m depth in Mol in cooperation with France, Germany, Japan and Spain. In 2002 ONDRAF published a major study (SAFIR 2) on its HLW/SNF disposal plans.
Approaches to Siting *Siting process; current status*	Since Belgium has not decided on a policy for the long-term management of radioactive waste, no siting criteria has been developed at this time. Nevertheless, the study of HLW disposal in Belgium started in the mid-1970s. Most effort was put into research of the Boom clay beneath the Mol/Dessel nuclear zone. In 1990, the SAFIR Evaluation Commission concluded that this decision had been the right one but that it might also be worthwhile also to consider other locations, like, e.g. the Doel nuclear zone with its underlying Ypresian clay. Hence, a research program into the clays at Doel was embarked upon in the early 1990s. When it is time to establish siting criteria for a HLW/SNF disposal facility, Belgium expects to use a global approach involving assessment and optimization of the performance of the disposal system as a whole, rather than using exclusion criteria linked to various characteristics of the geosphere.

WASTE MANAGEMENT: BELGIUM	
Finance and Economics *Cost estimates for disposal; financing method*	ONDRAF/NIRAS has carried out a detailed assessment of the cost of implementing geological disposal for HLW/SNF in Boom Clay. This cost assessment has, however, been undertaken on the assumption that a common repository will be developed for all types of radioactive waste that are suitable for geological disposal. The costs were estimated at the end of 1997, ranging from 290 to 580 million Euro* for the direct disposal option, and ranging from 590 to 1500 million Euro for the complete reprocessing option (both at year 2000 economic conditions). These estimates include no R&D. However, approximately 150 million Euro were spent for R&D over the 1974–2000 period. ONDRAF/NIRAS has developed a tariff (fee) based financing system for waste that is to be transferred to ONDRAF/NIRAS. Waste producers will pay the tariff into a special fund, called the *long term fund*, established within ONDRAF/NIRAS. The tariffs are based on the following principles: • A distinction is made between "fixed costs" and "variable costs". • The fixed costs are charged to producers according to committed volumes. • Variable costs are charged to producers according to volumes delivered. These fees are specified in commercial contracts with the utilities and are therefore confidential. * 1 Euro = 1.61 CAD (2003)
Public Involvement *Approaches at national, state, and community levels*	Since Belgium has not decided on a policy for long-term management of HLW/SNF, the role to be played by local governments and the public has not been specified. However, it is expected that that an approach will be developed that will be similar to the open decision making process that is being used to reach a decision regarding disposal of LLW. This approach includes establishment of local partnerships in which local residents play a key role.
International Cooperation *Main international partners; major cooperative projects*	Belgium plays an active role in projects of the EU, the NEA and IAEA. In addition GIE EURODICE manages the work in the HADES-URF where also other NEA countries participates. Belgium has bilateral cooperative agreements with several organizations in the EU, as well as in Canada, Japan, Switzerland and USA. Belgium is a member of the International Association for Environmentally Safe Disposal of Radioactive Materials – EDRAM. The national waste agency, ONDRAF, is a member of ARIUS, the Association for Regional and International Underground Storage.
Useful Internet Sites *Sites of implementers,*	www.nirond.be (National Agency for Management of Radioactive Waste and Enriched Fissile Materials) www.electrabel.com (Reactor operator)

WASTE MANAGEMENT: BELGIUM	
regulators; government departments	www.fanc.fgov.be (Federal Agency for Nuclear Control)
Additional Information	Belgium has one of the longest-established research programs on deep geological disposal, including in-site work in the undergroud laboratory at Mol. This is the world's leading facility for investigations on argillaceous materials, especially plastic clay of the BOOM clay type.

WASTE MANAGEMENT: CHINA, PEOPLES REPUBLIC OF	
Nuclear Activities *Nuclear power program*	China operates six light water and two heavy water reactors with a total capacity of about 6,200 MWe, providing more than 1% of the national energy supply. China has one heavy water and three light water reactors with a total capacity of about 3,300 MWe under construction. China plans to install 20,000 MWe nuclear capacity by 2020. China also has all other NFC facilities (U-mining, fuel fabrication, reprocessing), but not yet HLW disposal.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	The Chinese main classification system is different from most other countries. However, China also has classes of low-, intermediate- and high level waste. The amount of SNF is estimated to reach 2,000 tonnes by 2015. After 2020, about 1,000 tonnes of SNF will be produced annually.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	The China National Nuclear Corporation (CNNC) is responsible for the transport of HLW and SNF, reprocessing of SNF, vitrification of liquid HLW, and final disposal. Since 1998, CNNC has been in a transformation process, breaking it up into constituent parts. The Commission of Science, Technology and Industry for National Defence (COSTIND) is the competent authorities of the nuclear industry, which takes overall responsibility for all facilities associated with nuclear fuel cycle and radioactive waste management. It is in charge of mapping out the study and development program on radioactive waste management, and organizing the formulation of relevant national regulations, criteria, standards and requirements on radiation protection and radioactive waste management. It also manages the external affairs in the nuclear field, and carries out international cooperation and exchange in the name of the China Atomic Energy Authority (CAEA), which again is a part of the administrative oversight body The State Commission on Science, Technology and Industry (SCSTI). On the governmental level, The State Environment Protection Agency (SEPA), independent of the nuclear industry, carries out supervision and management on the nuclear safety and radiation environment of civilian nuclear facilities. The National Nuclear Safety Administration (NNSA) – the independent Regulatory Authority – issues rules and regulations. Together with the SEPA and the Ministry of Health it is responsible for surveillance of civilian nuclear installations. Also the Ministry of Science and Technology is important for the nuclear industry.

WASTE MANAGEMENT: CHINA, PEOPLES REPUBLIC OF	
	The fundamental institutional framework for radioactive waste management is outlined in • The Environment Protection Act • Regulations on the Safety Supervision and Control for Civilian Nuclear Installations. • The Atomic Energy Act (in preparation) • The Radioactive Pollution Prevention Act (in preparation)
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	When China started to develop nuclear power, a closed fuel cycle strategy was formulated. The SNF activities involve: at-reactor storage, away from reactor storage and reprocessing. SNF will be reprocessed; the HLW will be vitrified and disposed of in a deep geological repository. The repository will be a shaft-tunnel model, located in saturated granite. A pilot reprocessing plant is under construction. A full-scale commercial reprocessing plant will follow.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	Construction of a centralized SNF storage facility started in 1994. The initial stage will have a capacity of 550 tonnes. In 1985, CNNC proposed an R&D program for the deep geological disposal of HLW. The goal of this stage is to have an operational repository by 2040. In 1985, an Expert Group was established to coordinate the HLW geological disposal. This group is responsible for R&D programs related to site characterization, repository design, safety analysis and performance assessment. At present, the leading institute of the Expert Group, the Beijing Research Institute of Uranium Geology (BRIUG), is conducting a preliminary site-characterization project within the general area recognized as having the most potential, Beishan, for an URL and future HLW repository. Drilling of the first two boreholes was completed in 2001 and the preliminary findings are favourable.
Approaches to Siting *Siting process; current status*	In 1985, CNNC proposed an R&D program for the deep geological disposal of HLW. The program is divided into four phases: • Technical Preparation Phase (1986-1995): Planning, site screening, feasibility studies and R&D. • Geological Study Phase (1996-2010): Systematic studies of site screening, site characterization, performance assessment, methodology of environmental impact assessment, model development, and buffer/backfill materials are carried out. • *In situ* Test Phase (2011-2025): An URL will be built, and detailed site evaluation, *in situ* heater tests, tracer tests, and demonstration of disposal technology will be carried out. • Repository Construction Phase (2025-2040): The design and construction of the repository will be carried out.

WASTE MANAGEMENT: CHINA, PEOPLES REPUBLIC OF	
Finance and Economics *Cost estimates for disposal; financing method*	No public information available.
Public Involvement *Approaches at national, state, and community levels*	No public information available.
International Cooperation *Main international partners; major cooperative projects*	China is a member of the IAEA. Russia is the major international partner of China in the nuclear power area. China is cooperating with France in the siting process for a repository in the Beishan region.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.most.gov.cn (Ministry of Science and Technology) www.costind.gov.cn (Commission of Science, Technology and Industry for National Defence)
Additional Information	China has plans to be a major nuclear power user. It also has vast low-population areas. This has led to China often being listed amongst the possible host countries for an international repository and interest has been shown by Chinese officials.

<table>
<tr><th colspan="2">WASTE MANAGEMENT: CZECH REPUBLIC</th></tr>
<tr><td>Nuclear Activities

Nuclear power program</td><td>The Czech Republic has four light water reactors in operation with a total capacity of about 1,600 MWe at the Dukanovy plant site. This site accounts for some 19% of the national electricity production.

At a second site, Temelin, two new light water reactors with a total capacity of about 1,800 MWe are in the trial operation stage.

The projected lifetime for the reactors is 40 years.</td></tr>
<tr><td>Waste Categories and Quantities

Categorisation of radioactive wastes; quantities of SNF and HLW</td><td>The Czech Republic operates with the following main waste categories
• Transition RAW.
    o This roughly corresponds to Short-Lived Very Low Level Waste (VLLW-SL) as used in some other countries.
• LILW-SL – Short-lived Low and Intermediate Level Waste
• LILW-LL – Long-lived Low and Intermediate Level Waste
• HLW – High Level Waste

The total amount of SNF projected to be discharged from the six units over their operating life is estimated to about 3,500 tonnes.</td></tr>
<tr><td>Legal and Regulatory Framework

Implementing and regulatory bodies; advisory groups; main legislative instruments</td><td>The implementing organisation is the Radioactive Waste Repository Authority (RAWRA), which
• is responsible for implementation of radioactive waste disposal, and
• calculates and proposes fees.

In addition, the Ministry of Finance is responsible for the management of the funds in the Nuclear Account.

The regulatory authorities are:
• The State Office for Nuclear Safety which monitors and regulates nuclear safety and radiation protection
• Czech Mining Office which monitors and regulates geological and mining activities

The Government approves plans and budget for RAWRA.

The fundamental institutional framework for radioactive waste disposal (such as the financing system, implementing body, and requirements) is stipulated in the Atomic Act.</td></tr>
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WASTE MANAGEMENT: CZECH REPUBLIC	
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	According to the Atomic Act, SNF is not considered radioactive waste until it has been declared so by its owner or by the State Office for Nuclear Safety. Nevertheless, the Czech Republic is officially following the open fuel cycle policy, and disposal of SNF in a deep geological repository is the long-term strategy. A new strategy document “Concept of Radioactive Waste and Spent Fuel Management” was published by the Government in 2002. The national strategy being followed with top priority involves implementing a repository in a granitic formation. The official policy document states that the option of disposal in an international repository has not been excluded, although it notes the associated problems.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	The current facilities for SNF management consist of spent fuel pools at the Dukovany and Temelin sites, as well as a dry interim storage facility for SNF at the Dukovany site. The dry storage facility at Dukovany has been in operation since 1995 and is expected to reach its capacity of 600 tonnes SNF in 2005. Preparations are under way to build new storage facilities. The currently preferred option is to build separate dry cask storage facilities at each NPP site. The characteristics of the proposed repository are: • Capacity as necessary. • Host rock is granite. • 500-1000 m underground. • Engineered barriers consist of steel containers and clay/bentonite buffer materials. It is anticipated that the deep repository will, apart from SNF and HLW, also accommodate all radioactive wastes that cannot be deposited in near-surface repositories.
Approaches to Siting *Siting process; current status*	The Czech Geological Survey performed the preliminary geological screening. It was completed in 1992 and resulted in the selection of 27 promising areas in different host rocks. The preliminary site selection was completed in 1998 and resulted in eight sites chosen for further investigation. The further time schedule for the anticipated repository is as follows: • Investigation of eight pre-selected sites by 2005. • Proposal for two final sites by 2015. • Confirmation of the selected site by 2025. • Permit for characterization and URL by 2030. • Construction licence by 2045. Commissioning of repository in 2065.

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<tr><th colspan="2">WASTE MANAGEMENT: CZECH REPUBLIC</th></tr>
<tr><td>Finance and Economics

Cost estimates for disposal; financing method</td><td>RAWRA plans to dispose of, in a single facility, all radioactive waste, including low level waste, after the existing repository for low level waste is filled up. The cost estimation is as follows:

Cost element — Cost* (million CZK** 1999)
R&D — 5,240
Public relations, legislation — 200
Designing support and studies — 620
Total building cost — 7,517
Operation — 23,065
Closure — 300
Total — 46,942

* The costs specified above do not include any compensation for local communities or costs of transportation and storage of SNF. Storage and transportation of SNF is included in the operational costs of NPPs.
** 1 CZK = 0.05 CAD (2003)

The NPP operator pays levies into a Nuclear Account according to the average production of electricity in the NPP in the past five years. The present rate is 0.050 CZK/kWh.

However, the Nuclear Account does not cover the costs of transportation and storage of SNF, and decommissioning of nuclear power plants.

Generators are required to create a financial reserve for decommissioning nuclear installations.</td></tr>
<tr><td>Public Involvement

Approaches at national, state, and community levels</td><td>In the autumn of 2000, RAWRA established contacts with communities in the eight regions that had been selected during the siting process. In the spring of 2001, RAWRA initiated establishment of four Boards whose membership includes the mayors and chairmen of local elected councils from the regions that include sites being studied. The purpose of these Boards is to involve local representatives in the siting process.
In addition, public hearings concerning the site selection will be conducted as part of the preparation of the environmental impact assessment, as required by the Environmental Impact Assessment Act.
RAWRA has also carried out various activities to enhance understanding of media, central and local administrations and professionals and residents in the region:
• Meetings and seminars.
• Technical visits to nuclear facilities.
• Short TV documentaries.
• Establishment of an information centre in the national capital.</td></tr>
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WASTE MANAGEMENT: CZECH REPUBLIC	
International Cooperation *Main international partners; major cooperative projects*	Bilateral cooperation framework agreements have been signed between RAWRA and ENRESA (Spain), NAGRA (Switzerland), POSIVA (Finland) and RAWRA have taken part in specific projects with SKB (Sweden), GRS (Germany) and Decom (Slovakia). With RAWRA's support, relevant Czech institutions have been involved in the EC MOST (Molten Salt Rector Technology) project which summarises and classifies knowledge acquired to date on the reprocessing, recycling and transmutation of SNF. The Czech Republic participates in R&D at the Grimsel URL in Switzerland.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.sujb.cz (State Office for Nuclear Safety) www.surao.cz (Radioactive Waste Repository Authority (RAWRA)) www.nri.cz (Nuclear Research Institute)
Additional Information	

<table>
<tr><th colspan="2">WASTE MANAGEMENT: FINLAND</th></tr>
<tr><td>Nuclear Activities

Nuclear power program</td><td>Four light water nuclear power reactors were put into operation in Finland between 1977 and 1982; two are of western design and two are Russian.
The four reactors are operated by two utilities, FPH and TVO, and supply some 28 % of the national electricity production. Their total capacity amounts to about 2,700 MWe.
A fifth reactor will be build in the near future; the favoured design is the European pressurized water reactor (EPR).</td></tr>
<tr><td>Waste Categories and Quantities

Categorisation of radioactive wastes; quantities of SNF and HLW</td><td>Finland operates with the following waste categories
VLLW - Very low-level waste.
Such waste can be reused, recycled or disposed of in landfills.
LILW - Low and intermediate level waste.
This waste is disposed of in the bedrock at the power plant sites. The TVO repository lies between 60 and 95 deep in tonalite bedrock. The FPH repository lies at approximately 100 m depth in granite bedrock.
SNF - Spent nuclear fuel.
This waste will be disposed of in a future repository near the TVO plant.
About 1,130 tonnes of SNF had been discharged from the Finnish NPPs by the end of 2000.
Finland assumes between 40 and 60 years lifetimes for its four (five) reactors. The corresponding total amount of SNF to be disposed of is estimated to be between 2,600 and 4,000 tonnes.</td></tr>
<tr><td>Legal and Regulatory Framework

Implementing and regulatory bodies; advisory groups; main legislative instruments</td><td>The implementing organisation is Posiva Oy. Posiva was established in 1995 as a private company by the two nuclear utilities FPH and TVO to carry out the disposal of SNF.

The regulatory authority is the Radiation and Nuclear Safety Authority (STUK).
STUK:
proposes regulatory guidelines,
is responsible for technical and safety reviews of license applications, and
monitors the scientific and technical validity of Posiva activities.
The responsible governmental authority is the Ministry of Trade and Industry (MTI).
MTI:
establishes policies,
makes decisions in principle on project plans and sites on the basis of the implementing organisation’s application,
grants licenses,</td></tr>
</table>

WASTE MANAGEMENT: FINLAND	
	• issues general safety regulations, and • is responsible for the management of the State Fund for radioactive waste storage. The fundamental legislative framework for radioactive waste management in Finland comprises: • Nuclear Energy Act (1988) • Nuclear Liability Act (1989) • Decree on the State Nuclear Waste Management Fund (1988) • Environmental Impact Assessment Act (1994)
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	The Finnish fuel cycle is based on the once-through principle. Historically, the part of the Finnish SNF from the IVO (FPH) reactors used to be returned to the fuel supplier Russia. However, an amendment to the Nuclear Energy Act was passed in 1994 stating that all SNF generated in Finland has to be treated, stored and disposed of in Finland. Consequently, in 1995, the joint waste management company Posiva Oy was established by FPH and TVO for taking care of the disposal of spent fuel. All SNF from the NPPs will be stored on the plant specific sites until it is disposed of. The on-site storage facilities are of the wet (pool) type. Finland is planning to establish a deep geological repository for SNF in Olkiluoto, near the TVO NPP. The primary design parameters are: • Capacity for between 2,600 and 4,000 tonnes SNF • Host rock is crystalline (granite) • 400 - 700 m underground • Engineered barriers consist of copper canisters with cast iron inserts and bentonite clay as buffer materials in individual disposition holes. The necessary encapsulation facility will be constructed at the same site as the repository.

WASTE MANAGEMENT: FINLAND	
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	All SNF generated at the TVO plant is stored on-site. Previously the SNF of the FPH plant was transported to the Mayak facilities in Russia after interim storage of a few years. After SNF shipments to Russia were terminated at the end of 1996, SNF of the FPH plant has also been stored on-site. An underground rock laboratory, Onkalo, is being constructed at the proposed repository site near Olkiluoto. The application for the construction license for the deep geological repository is scheduled to be submitted by the end of 2010 and the operating license application around the year 2020. No other types of wastes are expected to be disposed of together with SNF. Posiva operates the Olkiluoto Research Tunnel (granite) at between 60 and 100 m depth in cooperation with Sweden.
Approaches to Siting *Siting process; current status*	Following a Government decision on spent fuel management, the project for siting of the SNF disposal facility was started in 1983 with a country wide screening carried out by TVO. After preliminary site investigation of five areas between 1987 and 1992, a detailed investigation of four sites was performed during the years 1993-1999 by TVO and, after its establishment, by Posiva. Environmental impact assessment and initial safety assessment were carried out at each of the four sites. In 1999, Posiva proposed, in a Decision-in-principle application, to site the disposal facility for SNF at Olkiluoto in Eurajoki, a couple of kilometres from the NPP. This application was approved by the municipality of Eurajoki in January 2000, the Finnish Government made the Decision-in-principle in December 2000 and the Parliament endorsed it in May 2001.

<table>
<tr><th colspan="2">WASTE MANAGEMENT: FINLAND</th></tr>
<tr><td>Finance and Economics

Cost estimates for disposal; financing method</td><td>The total cost, including all costs of decommissioning and final disposal, is estimated to be about 1.3 billion Euro* with no discounting. This figure breaks down as follows.

Cost element — Estimated cost (million Euro 2000)
Interim storage of SNF — 173
Transportation of SNF — 28
Construction of the disposal facility — 222
Operation of the disposal facility — 521
Decommissioning and sealing of the disposal facility — 48
R&D including siting and administration — 202
Regulatory/institutional control — 44
Real estate taxes — 49
Total — 1,287

The utilities are obliged to set aside a certain amount of money each year to the State Nuclear Waste Management Fund. The annual contributions to the Fund are not based on a fee per kW•h. However, the cost for radioactive waste management, including decommissioning, is calculated roughly to be about 0.0023 Euro/kW•h, which would be equivalent to approximately 10% of the total power production cost.

* 1 Euro = 1.61 CAD (2003)</td></tr>
<tr><td>Public Involvement

Approaches at national, state, and community levels</td><td>In accordance with the Nuclear Energy Act, acceptance by the host municipality is a prerequisite for the Decision-in-principle.

In 1987, when the first field investigation began, the implementing organisation and the candidate municipalities established co-operation groups to exchange information. In the past few years, key issues such as the results of the environmental impact assessment (EIA) have been raised and discussed extensively by the groups. The initial cooperation groups continued its activities since 1987, and new groups were established in 1997.

In the past, the following methods have also been used by Posiva to interact with the public:
• Newsletters on EIA were distributed to each household in the candidate municipalities. Explanatory material was made public at Posiva’s local offices.
• Public events and small group meetings were organized.
• Exhibitions were organized to describe the site investigations and present the results of the EIA, including opportunities for the public to provide comments and make their opinions known.
• Interviews with citizens and discussions in newspapers were organized.

STUK has also conducted long term interactions with inhabitants and representatives of the municipalities by visiting them, organizing seminars and meetings, and disseminating materials.</td></tr>
</table>

WASTE MANAGEMENT: FINLAND	
	As a result, the municipal council of Eurajoki, where the Olkiluoto site is located, approved the siting proposal with a clear majority.
International Cooperation *Main international partners; major cooperative projects*	Finland plays an active role in projects of the EU, the NEA and IAEA. Posiva works very closely with its Swedish sister, SKB, and has bilateral cooperative agreements with several organizations in the EU, as well as in Canada, Japan, Switzerland and USA. In addition Posiva manages the work in its Olkiluoto laboratory where also Sweden participates. Correspondingly, Posiva is responsible for the safety analysis section of the tests carried out in the Äspö Hard Rock Laboratory in Sweden. In 2002, Posiva concluded a cooperation agreement with its counterpart ANDRA of France. The agreement concerns the use of methods and techniques designed for the selection and assessment of final disposal sites in granite. Finland is a member of the International Association for Environmentally Safe Disposal of Radioactive Materials – EDRAM.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.stuk.fi (Radiation and Nuclear Safety Authority) www.posiva.fi (SNF disposal implementing organisation)
Additional Information	Finland, with its neighbour, Sweden, is recognised to be amongst the world's leading countries in radioactive waste management. The small size of the implementing agency, the efficiency of its work (especially its cooperation with Sweden) and the well organised interactions with local communities all serve as positive examples in the waste management community.

WASTE MANAGEMENT: FRANCE	
Nuclear Activities *Nuclear power program*	The French nuclear power plant fleet comprises a total of 58 standardised light water reactors with power ranging from 900 MWe to 1450 MWe The reactors were commissioned between 1977 and 1999 and are distributed over 19 EDF sites. France also has one fast breeder reactor in operation. The reactors supply some 77% of the national energy production. Their total capacity amounts to about 63,100 MWe. Nuclear power is, and will remain, a cornerstone in the French energy policy. France also has all other NFC facilities (U-mining, fuel fabrication, reprocessing), but not yet HLW disposal.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	France operates with the following main waste categories • VLLW – Very Low Level Waste • LILW-SL – Short-lived Low and Intermediate Level Waste • LLW-LL – Long-lived Low Level Waste • ILW-LL – Long-lived Intermediate Level Waste • HLW – High Level Waste About 1,150 tonnes of SNF are being unloaded from French reactors each year. After a cooling period in the fuel building pools in the nuclear units, spent fuel assemblies are shipped to the COGEMA plant at La Hague for eventual reprocessing. To avoid accumulating quantities of separated plutonium for which there would be no use, the SNF is reprocessed as and when uses for the extracted plutonium appear. This leads today to the annual reprocessing of about 850 tonnes of fuel, out of the 1,150 unloaded from the reactors. At the end of 2002, about 7,200 tonnes of French fuel was stored at La Hague and 3,600 tonnes in EDF's nuclear power plants. Apart from the French fuel, the pools at La Hague contained about 450 tonnes of fuel from Germany, Switzerland and the Netherlands at the end of 2001. The annual production of HLW is about 155 m^3. The total volume of HLW in the interim storage facilities at the end of 2001 is 1,500 m^3. The total amount of vitrified HLW to be generated by the present NPPs is 3,500 m^3 and the total amount of spent fuel is 15,000 tonnes.

<table>
<tr><th colspan="2">WASTE MANAGEMENT: FRANCE</th></tr>
<tr><td>Legal and Regulatory Framework

Implementing and regulatory bodies; advisory groups; main legislative instruments</td><td>The implementing organisation is the National Radioactive Waste Management Agency, Andra, which
is in charge of long term management of all radioactive waste.
The waste generators maintain the financial resources, which are provided to Andra according to a 5-year plan.

The regulatory authority is the General Directorate for Radiation Protection and Nuclear Safety (DGSNR), which
is responsible for nuclear safety and radiation protection regulation.
The French oversight/advisory body is the National Evaluation Commission (CNE), which
reviews high-level long-lived radioactive waste R&D programs and provides advice to the Parliament and the Government.
The responsible governmental authorities are:
Ministry of Industry
Ministry of the Environment
Ministry of Research
Ministry of Health
These ministries are in charge of developing policies and granting licenses.
Law No. 91-1381 of 30 December 1991 (the “Waste Act”) establishes the legal framework for the management of radioactive waste, including a framework specifically for the management of high-level long-lived waste.</td></tr>
<tr><td>SNF/HLW Management Strategies

National policy and strategy; planned infrastructure;</td><td>Spent nuclear fuel is not considered waste in France and it will be reprocessed.

All reprocessing is taking place at COGEMA’s site in La Hague.

According to a law passed in 1990, in 2006, the Parliament will discuss and decide on the national policy for management of long-lived high-level radioactive waste. The law requires the French waste management program to look at long term storage, deep disposal and partitioning and transmutation. This decision could also include specification of the time schedule for management of high-level long-lived radioactive waste.</td></tr>
</table>

WASTE MANAGEMENT: FRANCE	
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	In 2006, the Parliament will discuss and decide on the national policy for management of long-lived high-level radioactive waste. In 1998, the government approved construction of one URL in a clay formation in Eastern France and in 2000, Andra was granted a license to construct and operate an URL in the clay formations at Bure. At the same time, the Government established a mission to screen possible granite sites for construction of a second URL. This mission failed and, up to now, the site selection process for a granite URL has not been restarted. France also operates the Tournemire hard clay facility at 250 m depth in cooperation with Germany. In the past, France operated the following two URLs: • The Amelie bedded salt URL, from 1986 to 1992 • The Fanay-Augeres granite URL, from 1980 to 1990.
Approaches to Siting *Siting process; current status*	In 1987, Andra initiated activities to site a geological repository and develop plans for four sites (granite, clay, salt and shale). In 1990 however, there was substantial protest from the public, including certain organizations and politicians. The situation was so serious that the Prime Minister announced a moratorium on further siting. It was then decided to initiate a volunteering process in which communities agreeing to accept an underground laboratory (which could subsequently be developed into a deep repository) would receive financial compensation. This led to Andra implementing the URL at Bure but a second site in granite has not been identified.
Finance and Economics *Cost estimates for disposal; financing method*	Since the policy on the management of the back-end of the nuclear fuel cycle has not been established, an official cost estimation is not available. The total whole life cost of managing radioactive waste is estimated at 38.41 billion Euro* (1999 prices). The waste generators are responsible for financing the expenses of the Andra's nuclear waste management program. They are also required to build up reserves to pay the present and future costs of waste management. The operators are requested to set up balance sheet provisions to cover these future liabilities. Confidence that adequate funds will be available in the future is based on the assumption that electricity generation and sale will continue to raise sufficient cash flow to finance liabilities as and when they arise. * 1 Euro = 1.61 CAD (2003)

WASTE MANAGEMENT: FRANCE	
Public Involvement *Approaches at national, state, and community levels*	During the deliberations conducted by Parliament in 1990, a new platform was issued: responsibility, transparency, and democracy. The law of 30 December 1991 states that elected representatives and members of the public must be kept informed of the activities involved in establishing and conducting research in URLs. A nuclear waste negotiator (M. Bataille) was nominated, with the task of finding volunteer host communities for an URL and possibly a repository. The decrees of 3 August 1999 require establishment of an information and monitoring committee, consisting of elected representatives; representatives of the government, environmental groups and unions; representatives of other organisations and an administrator of the URL. The committees can organize public hearings.
International Cooperation *Main international partners; major cooperative projects*	Andra has bilateral agreements with several other national waste management agencies. Interesting because of the current impasse in granite in France is that in 2002, Andra concluded a cooperation agreement with its counterpart Posiva of Finland. The agreement concerns the use of methods and techniques designed for the selection and assessment of final disposal sites in granite. France plays an active role in projects of the EU, the NEA and the IAEA and is a member of the International Association for Environmentally Safe Disposal of Radioactive Materials – EDRAM. In particular, Andra is participating actively in the 6^{th} Framework Program for Research and Development of the European Union as well as in various working groups of the OECD/NEA Radioactive Waste Management Committee (RWMC) and the Forum for Stakeholders' Confidence (FSC). Of particular interest is the detachment of Andra experts to the granitic site of Beishan, China, to study the possibility of implementing a deep geological repository for HLW in that country. France also participates in URL research in Belgium, Canada, Germany, Sweden and Switzerland.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.andra.fr (National Radioactive Waste Management Organization) www.cogema.fr (Nuclear Fuel Cycle Company) www.irsn.org (Institute for Radiological Protection and Nuclear Safety) www.francenuc.org (Public pressure group site)

WASTE MANAGEMENT: FRANCE	
Additional Information	Although there are nuclear critics in France, the nuclear program of EDF is the largest of any utility world-wide and France is a major exporter of electricity in Europe. The need for a publicly accepted waste strategy has been increasingly recognized and the implementer, Andra, has taken a major role in dialogue initiatives including the Forum on Stakeholder Conference (FSC) of the NEA.

WASTE MANAGEMENT: GERMANY	
Nuclear Activities *Nuclear power program*	Germany has 18 light water nuclear power reactors in operation and 19 shutdown nuclear power reactors. The capacity of the operating reactors amount to about 21,000 MWe and represents just over 30 % of the national electricity production. After the national elections in 1998, a red/green coalition came to power in Germany. The new coalition Government, which was re-elected in 2002, has made sweeping changes to the power producing industry in general and to the nuclear power industry in particular. Instead of promoting nuclear power as a cornerstone of the national energy supply, the new government has decided to phase out nuclear power completely by around 2020.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	Germany operates with the following waste categories • Heat Generating Waste o This roughly corresponds to the category High Level Waste (HLW) as used in some other countries. • Waste with Negligible Heat Generation o This roughly corresponds to the category Low and Intermediate Level Waste (LILW) as used in some other countries. The latest estimate of the amount of radioactive waste that will be generated in Germany includes the following two separate inventories: • 22,000 m^3 of HLW (including the overpacks), and • 9,000 tonnes of SNF (this SNF will all have been generated by around 2020).
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instrumentsa*	Implementing Organisations • BfS - Federal Office of Radiation Protection. o Is responsible for HLW and SNF disposal. o Is a subordinate body within the Ministry of the Environment (BMU). • DBE - German Company for Construction and Operation of Waste Repositories. o Is delegated by BfS to implement the HLW and SNF disposal. The operators of the nuclear facilities are responsible for maintaining financial resources. Regulatory Authorities • BMU – Federal Ministry of Environment, Nature Conservation and Nuclear Safety. o Establishes safety requirements. • Federal States (delegated) o Are responsible for granting construction and

WASTE MANAGEMENT: GERMANY	
	operational licenses o Oversees all licensing activities. Advisory Bodies • RSK – Reactor Safety Commission. • SSK – Commission on Radiological Protection. The disposal if radioactive waste in a final repository is governed by the following set of laws and regulations: • The Atomic Energy Act (1959) • Federal Mining Act • Precautionary Radiation Protection Act (1986) • Radiation Protection Ordinance. • Safety Criteria for the Disposal of Radioactive Waste in a Mine. • Act of the Assessment of Environmental Impacts (1990). The Atomic Energy Act was last amended on April 22, 2002. This amendment formalised the new nuclear policy of Germany and represents the legal basis for the phase out of nuclear power.
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	According to the Atomic Energy Act, the final disposal of radioactive waste is the responsibility of the Federal Government. The final disposal concept anticipates the disposal of all waste in deep geological repositories. The original German nuclear program anticipated the disposal of non-heat generating waste in the Konrad repository (iron ore) and the heat generating waste, including SNF, in the Gorleben repository (salt stock). The government inaugurated in 1998 has committed itself to change this policy in favour of a single repository for all types of radioactive waste, to be commissioned around 2030. The Consensus Agreement signed between Government and the nuclear utilities in 2001 established a moratorium on site investigation work at Gorleben. It listed a number of “open technical issues” to be clarified before proceeding further. It was also decided that a new national site selection procedure shall be initiated, starting from a “blank map of Germany”. Hence, Konrad and Gorleben have, by definition, no special position in the current German waste disposal plans. The original German program was also based on the closed fuel cycle with the corresponding reprocessing of SNF. Due to the phase out of nuclear power by 2020, no SNF will be sent to reprocessing after July 1, 2005.

WASTE MANAGEMENT: GERMANY	
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	All the NPPs have wet storage pools for SNF. Historically, Germany has two centralised interim storage facilities, both dry, and two on-site interim storage facilities, one wet and one dry, for SNF. The interim storage site at Gorleben also has a pilot conditioning plant for SNF. In order to reduce transport of SNF on German territory to a minimum until a final repository is operational, the latest revision of the Atomic Energy Act orders the power plant operators to construct interim storage facilities for SNF inside the closed area of the plant or near their sites. Consequently, the power plant operators have applied for an additional 12 on-site interim storage facilities. The licensed lifetime of the on-site interim storage facilities will be limited to 40 years in order to make sure they do not become de facto final repositories. All on-site interim storage facilities are expected to enter into operation by 2005. HLW from the SNF reprocessing in France and the UK will continue to be delivered to one centralised dry storage facility until the current reprocessing contracts are completed. The last canister containing vitrified waste will be delivered by the end of 2008. The current German policy is to have a single deep geological repository for all types of radioactive waste commissioned around 2030. Germany operates the Asse rock salt URL in cooperation with France, the Netherlands and Spain.
Approaches to Siting *Siting process; current status*	In 1999 the BMU appointed an expert group, the AkEnd, whose mandate it was to develop a comprehensive procedure for the selection of one single site for radioactive waste disposal. The AkEnd delivered their final report in December 2002. The AkEnd proposal foresees that public discussion and agreement on the selection procedure, including its implementation in a law, will be completed by the end of 2004. The execution of the site selection procedure should then take place between 2005 and 2020, immediately followed by the construction of the repository itself. It is a prerequisite for new site selection process proposed by AkEnd that it shall start from a “blank map of Germany”. The new siting process has not started. The German utilities have refused to participate in and fund the process, since they argue that with Gorleben and Konrad they have already financed the search for two sites.

WASTE MANAGEMENT: GERMANY	
Finance and Economics *Cost estimates for disposal; financing method*	As a result of the Federal Government's decision in 2000 to abandon nuclear energy, and modification of the waste management policy (i.e. pursuing the concept of a single repository for all kinds of radioactive waste), the cost estimates carried out in 1997 based on the Gorleben and Konrad projects are no longer valid. A new cost estimate will be prepared in the future based on a new policy. Consequently, there is no basis for calculation of the fee at the present time. The cost estimate carried out in December 1996 for the Gorleben repository up to operation was 2,290 million Euro* and for the Konrad project was 1,370 million Euro* (January 1997). The costs of disposal facilities were split between site characterisation, licensing, design, construction, operation and closure. According to the Atomic Energy Act, waste producers must bear the costs of safe waste management and disposal. Consequently, utilities running NPPs and industrial companies operating nuclear facilities must build up reserves to pay for future waste disposal and decommissioning of facilities. The nuclear power plant operators have built up reserves for future costs of waste disposal and decommissioning. Responsibility for paying the costs of radioactive waste disposal will be shared among the various waste generators. The NPP owners will pay the major part; their shares are about 96% for Gorleben (heat generating waste) and about 64% for Konrad (non heat generating waste). * 1 Euro = 1.61 CAD (2003)
Public Involvement *Approaches at national, state, and community levels*	The AkEnd has stressed the need for public involvement in all stages of any new repository siting procedure. The proposed site selection process will be conducted in three general phases. The public involvement process will be different for each of these phases, as discussed below: • In the first phase, a Committee will develop the siting process and the site selection criteria. The records of these discussions will be provided to the public. • In the second phase, activities such as dialogues with stakeholders will be conducted with the intent of gaining public acceptance of the siting process (as proposed by the Committee during the first phase), thus allowing the siting process to be formally established through legislation. • In the third phase, representatives of communities will be involved in the actual site selection process. The AkEnd members themselves were divided on the question of whether a potential repository host community should have a veto right.

WASTE MANAGEMENT: GERMANY	
International Cooperation *Main international partners; major cooperative projects*	Germany plays an active role in the projects of the EU, the NEA and IAEA. Germany is a member of the International Association for Environmentally Safe Disposal of Radioactive Materials – EDRAM. GSF manages international collaborative work in its Asse URL. In addition Germany participates in URL projects in Belgium, France, Sweden and Switzerland.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.bmu.de (Ministry of the Environment) www.bfs.de (Federal Office of Radiation Protection) www.dbe.de (German Company for Construction and operation of Final Repositories)
Additional Information	Germany has changed from being a European or world leader in nuclear technologies (including disposal) to being the prime proponent of shutting down nuclear power. Whether this strategy will survive future changes of Government is an open question.

WASTE MANAGEMENT: HUNGARY	
Nuclear Activities *Nuclear power program*	There are four light water reactors at one nuclear power plant in operation in Hungary. The reactors have a capacity of approximately 1,800 MWe and supply some 40% of the national energy production. At present, investigations and discussions on extending the planned 30-year lifetime of the reactors by about 20 years are in progress.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	Hungary's waste classification system is based on activity concentration. The three categories are: • Low Level Waste (LLW) • Intermediate Level Waste (ILW) • High Level Waste (HLW) For waste containing trans-uranic elements, a separate classification is applied. The four reactors generate about 46 tonnes SNF per year. At the end of 2002, about 254 tonnes of SNF were in the storage pools at the NPP and a further 353 tonnes at the Interim Spent Fuel Storage Facility. The total amount of SNF to be disposed of at the end of the 30-year lifetime of the reactors is expected to be about 1,300 tonnes, not including the 273 tonnes of SNF already shipped back to Russia. If a 20 year lifetime extension is accomplished, this will result in another 890 tonnes.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	The implementing organization is the Public Agency for Radioactive Waste Management (PURAM), which is responsible for: • Implementation of SNF storage and disposal. • Preparation for HLW disposal. • Preparation of waste management cost estimates. PURAM is a state-owned, non-profit organisation established by Government decree No. 240/1977. A department of the Hungarian Atomic Energy Authority (HAEA) manages the Central Nuclear Financial Fund (for radioactive waste management). Another department of HAEA – the Nuclear Safety Directorate (NSD) – is the competent Hungarian regulatory authority responsible for regulation and licensing of SNF storage and disposal. According to the Hungarian legislation, a facility is not a "nuclear" facility if no significant amount of fissile material is present.

<table>
<tr><th colspan="2">WASTE MANAGEMENT: HUNGARY</th></tr>
<tr><td></td><td>Therefore, the disposal of HLW from reprocessing, which contains only fission products, is regulated and licensed by the Public Health and Medical Officers Service (on behalf of the Minister of Health, Social and Family Affairs).

The Hungarian Geological Survey approves the PURAM's geological research plan and reports.

Two advisory bodies are of special importance:
Scientific Advisory Board.
Provides scientific oversight of PURAM activities.
Special Committee of the Hungarian Atomic Energy Commission.
Comments on and recommends policies and strategies for waste management and fund management.
The Minister of Economy and Transport supervises HAEA activities.

Environmental issues are within the competence of the regional environmental protection inspectorates under the Ministry of Environment and Water.

The Hungarian Government establishes policies and strategies for radioactive waste management.

The legal framework for radioactive waste management is provided through the Atomic Energy Act of 1996. Considerations of social-political issues concerning SNF and radioactive waste management are given in Act LIII of 1995 on Environmental Protection.</td></tr>
<tr><td>SNF/HLW Management Strategies

National policy and strategy; planned infrastructure;</td><td>Between 1989 and 1998, the major part of the SNF was shipped back to its country of origin, Russia. Since the beginning of the 90s, shipments to Russia became increasingly more difficult and expensive. As a result, a modular type dry Interim Spent Fuel Storage Facility was constructed. The facility was commissioned in 1997.

Presently, there is no final decision on the back-end of the fuel cycle, but – in order to calculate the future costs of radioactive waste and SNF management, as well as to assure the necessary funding – some assumptions need to be made. As a reference scenario the postulation of direct disposal of the SNF in Hungary was accepted.

Multinational disposal is also an option, however, and PURAM is member of Arius.</td></tr>
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WASTE MANAGEMENT: HUNGARY	
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	The Hungarian modular storage facility for SNF will have a capacity to store approximately 1,320 tonnes SNF. This is enough to store the current inventory of SNF assemblies, as well as those to be generated at the four reactors until the end of their 30-year operating lifetime. PURAM is presently developing a new strategy for radioactive waste disposal. The new policy will include strategies for closure of the nuclear fuel cycle and disposal of HLW resulting from SNF reprocessing. Development and approval of the plan is expected to take between 5 and 7 years. If geological disposal is the option chosen, then 20 to 25 years will be required for completion of research and siting activities. An additional 10 to 15 years is expected to be needed for licensing and construction activities. In 2000, PURAM prepared a plan where the direct disposal of SNF and other long-lived wastes in a deep geological repository was considered the reference scenario for long term management. The schedule for the establishment of the proposed repository would then be as follows: • 2003-2007: Selection of realistic scenarios. Preparation of work plans and carrying out investigations needed for establishing an underground research laboratory. • 2007-2012: Construction of the underground research laboratory. • 2033-2046: Construction of the geological repository. • 2047: Start of operation of the repository.
Approaches to Siting *Siting process; current status*	Investigations of sites suitable for use as a geological repository have been underway since 1993. However, after the government rejected the PURAM investigation plan in 1999, PURAM decided to develop a new policy on disposal of SNF and HLW, see above. Although one of the potential host rocks, clay-stone, has been thoroughly investigated, no specific features of a repository have been defined yet.

<table>
<tr><th colspan="2">WASTE MANAGEMENT: HUNGARY</th></tr>
<tr><td>Finance and Economics

Cost estimates for disposal; financing method</td><td>The total cost (at 2000 money levels) of radioactive waste management in Hungary is estimated at 359 billion HUF* This sum is made up of the following components (in billion HUF).

R&D 5.5
Interim Storage 58.3
Siting 20.5
Land Acquisition 1.0
Design 13.0
Licensing (regulatory) 2.0
Construction 127.8
Waste Transportation 33.6
Repository Operation 71.1
Closure and Institutional Control 26.5
Total 359.3

The financing system is based on a Central Nuclear Financial Fund to finance radioactive waste management (including storage and disposal of SNF), as well as decommissioning of nuclear facilities.

Payments into the Fund are set so that the Fund will cover all costs of radioactive waste and spent fuel management. In order to ensure the stability of the Fund, a contribution to the Fund is made by the Government based on the real rate of return on money in the Fund. The Hungarian Atomic Energy Authority is responsible for management of the Fund.

The fee charged to nuclear utilities was 1.18 HUF/kW•h in 2001. The fee is reviewed every year when the Parliament approves the national budget based on calculations made by PURAM.

* 1 HUF = 0.006 CAD (2003)</td></tr>
<tr><td>Public Involvement

Approaches at national, state, and community levels</td><td>The new policy on radioactive waste management presently developed by PURAM will be made available for open discussion to gain a wider range of consensus by radioactive waste management professionals and the public at large.

During the new siting process, an Environmental Impact Assessment (EIA) will be carried out as specified in the Act on Environmental Protection. Public hearings will be held for citizens in local and neighbouring municipalities and other interested groups as part of the EIA process.

In addition to the steps required by the legal requirements, various measures will be taken to promote public involvement in the siting process. These activities are anticipated to be similar to the activities carried out for other Hungarian nuclear facilities, as summarised below:

• First, a letter is sent to the municipality notifying them of the proposed Project. The letter also indicates that no decision has been made and the facilities would be built in areas</td></tr>
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WASTE MANAGEMENT: HUNGARY	
	where most of the residents would agree to the Project. Those who express interest or opinions are invited to information sessions that are organized to provide them with relevant information and to provide an opportunity for a consultation with them. • Next, technical visits to the nuclear facilities are organized. These visits provide occasions for members of the public to see the facilities and have contacts with people working in them. • Cultural and social events are organized to develop the mutual contacts between members of the communities and project personnel. • Finally, a "Social Control and Association" organization is established with participation of members of the public from villages near the possible facilities. This organization monitors the status of the investigation activities and provides the public with information on their status.
International Cooperation *Main international partners; major cooperative projects*	Hungary is participating actively in the working groups and on the committees of the different international organisations – IAEA, OECD/NEA and EU – responsible for radioactive waste management. The national waste agency, PURAM, is a member of the Club of Agencies, see chapter 3.1.4, and has a number of contacts with waste management organisations in other countries. Worth special mentioning is a bilateral agreement of cooperation on development, research and technological solutions for radioactive waste management with Belgium, and that the Spanish ENRESA was the successful bidder for advisory services to PURAM in developing a policy for the management of high-level and/or long-lived radioactive waste and SNF. PURAM is also a member of ARIUS, the Association for Regional and International Underground Storage, see chapter 3.1.4.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.haea.gov.hu (Hungarian Atomic Energy Authority) www.rhk.hu (Hungarian Waste Agency - PURAM)
Additional Information	

WASTE MANAGEMENT: INDIA	
Nuclear Activities *Nuclear power program*	India operates 12 heavy water reactors and 2 two light water reactors with a total capacity of about 2,700 MWe. They provide some 4% of the national energy supply; this is expected to reach 10% by 2005. India has 4 heavy water and 4 light water reactors with a total capacity of 3,600 MWe under construction. India's goal is to have about 20,000 MWe capacity by 2020. India also has all other NFC facilities (U-mining, enrichment, fuel fabrication, reprocessing, etc.), including heavy water production, but not yet HLW disposal. These nuclear activities are all undertaken by governmental organisations.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	India operates with the following main waste categories: • Low level waste - LLW • Intermediate level waste - ILW • High level waste - HLW Since India in principle reprocesses all of its SNF, it is not classified as waste. There are no official Indian data on the total quantity of SNF and HLW currently in storage in India available. US sources give the 2000 figure as 2,750 tonnes and the 2020 prediction as 15,150 tonnes.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	The nuclear power generation and related fuel cycle activities are under the Central Government. The Ministry of Power is concerned with perspective planning and policy formulation. The Central Electricity Authority (CEA) is responsible for technical coordination and supervision of programs. The Atomic Energy Commission is responsible for formulating the nuclear energy policy. All stages of the nuclear fuel cycle, including the back-end, are under the direct control of the Department of Atomic Energy (DAE). Tariffs for nuclear power generation are notified by DAE in consultation with CEA. The Nuclear Power Corporation of India Ltd (NPCIL) builds, owns and operates the nuclear power plants. The government wholly owns the company. So far, there is no equity participation by the private sector in the area of nuclear power generation. The independent regulatory agency is the Atomic Energy Regulatory Board (AERB).

WASTE MANAGEMENT: INDIA	
	The fundamental institutional framework for radioactive waste management comprises: • The Atomic Energy Act (1962) • The Radiation Protection Rules (1971) • Atomic Energy (arbitration procedure) Rules (1983) • Atomic Energy (working of mines, minerals and handling of prescribed substances) Rules (1984) • Atomic Energy (safe disposal of radioactive waste) Rules (1987)
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	Having little cooperation with other countries and having relatively little reserves of natural uranium but relatively significant reserves of thorium, India reprocesses its SNF. Accordingly, since all SNF will be reprocessed, it is stored in wet pools until reprocessing. India will dispose of HLW in a deep geological repository located in granite host rock.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	Currently, three regional SNF storage facilities are being constructed at different reactor sites to meet the storage requirements. The leading institution in the waste management area is the Bhabha Atomic Research Centre (BARC), which has developed the technology for and set up Indias' fuel reprocessing plants. Three reprocessing plants are operating at Kalpakkam, Tarapur and Trombay. Trombay also has a waste immobilization plant and an interim storage facility. Research is being performed on setting up a deep geological repository.
Approaches to Siting *Siting process; current status*	No public information available.
Finance and Economics *Cost estimates for disposal; financing method*	No public information available.
Public Involvement *Approaches at national, state, and community levels*	No public information available.
International Cooperation *Main international partners; major cooperative projects*	India is a member of the IAEA. Due to its rejection of the 1970 Nuclear Non-Proliferation Treaty (NPT), India has very little cooperation with other countries in the nuclear area and its nuclear strategy has been directed towards

WASTE MANAGEMENT: INDIA	
	complete independence and self-reliance.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.dae.gov.in (Department of Atomic Energy) www.npcil.org (Nuclear Power Corporation of India Ltd) www.barc.ernet.in (Bhabha Atomic Research Centre) www.igcar.ernet.in (Indira Gandhi Centre for Atomic Research)
Additional Information	India aims to be self sufficient in the nuclear area. Since it has limited uranium reserves, this aim has led it to initiate research into FBRs and the thorium fuel cycle. Being a nuclear weapons state, the line between the military nuclear program and the civilian nuclear program is hard to establish. Sometimes these programs overlap, which makes it difficult to obtain exact data for the civilian sector.

WASTE MANAGEMENT: ITALY	
Nuclear Activities *Nuclear power program*	Italy had a total of three light water reactors and one gas cooled reactor in operation between 1964 and 1990. Italy abandoned nuclear power following a national referendum in 1987, a year after the Chernobyl accident. Earlier, Italy was a leading nuclear nation in Europe and implemented pilot or test facilities for all parts of the nuclear fuel cycle, including reprocessing.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	Italy operates with the following main waste categories • Category I – Waste which decay in a few months to radioactivity level below safety concerns. • Category II – Waste which decay to radioactivity level of a few hundreds of Bq/g within a few centuries. • Category III – Long Lived and High Level Waste o IIIA – wastes with negligible heat production (e.g. cemented ILW) o IIIB – wastes with heat production (e.g. vitrified HLW) o IIIC – Spent Nuclear Fuel Some SNF has been reprocessed in the UK. Around 1995, Italy decided, on the basis of an economical and technical evaluation, to terminate SNF reprocessing and proceed with interim dry storage of the remaining SNF. Italy has about 1,000 m^3 of Category III waste including 300 canisters of HLW from reprocessing and 300 tonnes SNF.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	The management of the back end of the fuel cycle was earlier in the hands of ENEA but is now assigned to the company SOGIN. SOGIN has been operational since 1999; its shares are held by the Ministry of Economics and Finance, and the company operates under guidelines issued by the Ministry of Productive Activities. Italy intends to create a National Agency for the Management and Disposal of Radioactive waste. The regulatory and supervisory body is the Agency for Environmental Protection and Technical Services (APAT). APAT is under the supervision of the Ministry of the Environment. The Technical Commission for Nuclear Safety and Health Protection from Ionising Radiation gives technical advice concerning the granting of licenses for nuclear installations, and is composed of experts from APAT, various Ministries and from the National Agency for the New Technology, the Energy and the Environment (ENEA).

WASTE MANAGEMENT: ITALY	
	The major governmental institution is the Ministry for Productive Activities, which issues operating licenses for all nuclear and radioactive installations. For installations related to radioactive waste storage and disposal, the concerted agreement of the Ministries of Environment, Internal Affairs, Welfare, and Health is also required. The regulatory regime for nuclear activities is largely based on two acts: • Act no. 1860 of 31 December 1962 on the Peaceful Uses of Nuclear Energy. • Legislative Decree no. 230 of 17 December 1995 providing for the integration of six Euratom Directives concerned with radiation protection.
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	In 1999, the Ministry of Industry outlined its strategic decisions regarding the management of radioactive waste. Two of the main goals were: • Within a ten year period, the treatment and conditioning of all liquid and solid waste with a view to subsequent transport to a national waste repository. • Site selection and construction of a national repository for low and intermediate level waste, also within a decade. The same site would be used for the temporary storage of HLW and SNF. In November 2003, the Italian government issued a decree authorizing the construction of a repository for *all types* of radioactive waste near the village of Scanzano Jonico in southern Italy. After two weeks of non-stop public protests however, the Government retreated and modified the decree by removing the name of the village and replaced it with the formulation that the site for the repository was to be identified within a year. The decree will need to be confirmed by the Italian Parliament by the middle of January 2004.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	Until November 2003, it was the official policy of Italy to vitrify its liquid HLW and build on-site dry storage facilities for its SNF. The SNF would be emplaced in dual-purpose (transport/storage) casks. A national central facility for the interim storage of HLW and SNF was foreseen for the end of 2010. In November 2003, the situation changed suddenly with a governmental decree that stated that a site for a national repository for all types of nuclear waste should be identified within one year. No further technical information on the repository had been made publicly available as of December 2003. The unexpected decree on radioactive waste management has been connected to the Italian governments' ongoing efforts to consolidate its nuclear storage facilities to meet the threat of terrorist attacks.

WASTE MANAGEMENT: ITALY	
Approaches to Siting *Siting process; current status*	The relevant Ministries and regional authorities set up an expert group in January 2000. The groups' main objective was to identify and propose a procedure for the site selection that would achieve the required level of consensus from the public and local authorities. The expert group presented their preliminary conclusions on September 2001. In July 2002, the Government initiated a process aimed at the establishment of a body that would take care of the siting, construction and operation of the repository. With the decree issued by the Italian government in November 2003, it seems that the siting process will be accelerated. No information on the siting process itself had been made public as of December 2003.
Finance and Economics *Cost estimates for disposal; financing method*	In the 1980's, even though there were no precise laws on this specific matter, ENEL created a fund for plant decommissioning and a fund for SNF management. A multi-annual plan for financial provision was defined. (EURELECTRIC, 2001) Cumulated funds at the date of its constitution, which were transferred to SOGIN, amounted to about 750 million Euro*. This amount was adequate to complete decommissioning activities within the Safe Store strategy. Following the separation of SOGIN from ENEL, a funding mechanism was defined to provide resources for additional costs deriving from the different economic conditions. A Decree of the Ministry of the Industry issued on 26th January 2000 states that the above mentioned extra costs for SOGIN shall be financed with a levy on the price of the sold kWhs. Every year SOGIN shall present its program of future activities, with associated costs: on this basis, the national Authority for Electric Energy and Gas shall re-evaluate the amount of the price of the kWh due to SOGIN for the next three years; this re-evaluation will take into account economic efficiency criteria. For the year 2000 a provisional amount of ~0,031 Euro-cents per kWh was defined. * 1 Euro = 1.61 CAD (2003)
Public Involvement *Approaches at national, state, and community levels*	Until November 2003, it was the stated policy of Italy that all activities related to the localization and building of final repositories for radioactive wastes can only be performed if a wide consensus can be reached. This would require efforts towards communication and transparency. Moreover, the consensus could only be achieved as a result of efforts and strong cooperation between national and local authorities and the technical and political worlds. Two kinds of initiatives were carried out: • The Government defined an agreement with regional authorities in order to speed up a common progress towards the location of a final repository and to ensure the necessary transparency to the general public. • Since the commencement of its activities, SOGIN organized

WASTE MANAGEMENT: ITALY	
	meetings with local authorities to inform them about the main strategies. Since November 2003: The decree issued by the Italian government in November 2003 came as a complete surprise to the population of Italy, including the population of the village where the repository originally was supposed to be located. The consensus building approach with the population, which has become prevalent in most countries radioactive waste disposal programs, has obviously not been applied in the case of Italy.
International Cooperation *Main international partners; major cooperative projects*	Italy participates in several international cooperation projects developed under the aegis of the EU, the NEA/OECD and the IAEA. ENEA is involved in several international partitioning and transmutation projects such as: PARTNEW (partitioning of long lived radionuclides from HLW), the ADS (Accelerator Driven System) and recently applied to APAT for a preliminary authorization to carry out experimental activities on a TRIGA reactor. In the area of nuclear safety and environmental protection, APAT has signed bilateral agreements with its counterparts in China, France, Spain, UK and USA. The National Agency for the New Technology, the Energy and the Environment, ENEA, is a member of ARIUS, the Association for Regional and International Underground Storage.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.enea.it (Italian Agency for New Technology, Energy and the Environment) www.sinanet.apat.it (Agency for Environmental Protection and Technical Services) (Italian only) www.anpeq.it (National Professional Association of Italian Qualified Experts in Radiological Protection) (Italian only)
Additional Information	Earlier, Italy was a leading nuclear nation in Europe and implemented pilot or test facilities for all parts of the nuclear fuel cycle, including reprocessing.

WASTE MANAGEMENT: JAPAN	
Nuclear Activities *Nuclear power program*	As of the end of June 2001, 51 light water nuclear power reactors were in operation in Japan with a total capacity of about 45,000 MWe. Four units with a total capacity of 4,700 MWe are under construction, and another six units with a total capacity of 7,200 MWe are being planned. In addition, a prototype ATR was closed in March 2003 and a FBR was shut down after an accident involving release of liquid sodium coolant. Nuclear power supplies more than one third of the gross electric power demand.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	Japan operates with the following main waste categories • LLW – low level waste • TRU - long-lived wastes from reprocessing • HLW – high level waste Japan has adopted the closed fuel cycle. Hence SNF is not considered waste and will not be disposed of. The total amount of SNF stored in Japan as of early 2003 was approximately 11,000 tonnes. The total amount of SNF generated was approximately 17,000 tonnes. The total amount of vitrified HLW expected to be generated from reprocessing by 2020 is about 40,000 canisters. (Equivalent to approximately 54,000 tonnes SNF)
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	The Nuclear Waste Management Organisation of Japan (NUMO) was established in 2000 to be the HLW disposal implementing organization in Japan. NUMO was established by the private sector and was approved by the Minister of Economy, Trade and Industry (METI). NUMO is responsible for conducting the following activities: • Implementation of final geological disposal of HLW. • Collection of fees to provide funds to pay for NUMO's disposal activities. A separate Governmental entity, the Radioactive Waste Management Funding and Research Centre (RWMC) is responsible for management of the fund. The regulatory authority is METI through its Nuclear and Industrial Safety Agency. This agency establishes requirements and grants licenses. Nuclear oversight bodies consist of: • Atomic Energy Commission ○ Provides oversight on the Basic Policy and the Final Disposal Plan. • Nuclear Safety Commission. ○ Provides oversight on technical matters of the Basic Policy and the Final Disposal Plan.

<table>
<tr><th colspan="2">WASTE MANAGEMENT: JAPAN</th></tr>
<tr><td></td><td>
Provides oversight on regulation of nuclear safety.
Advisory Committee for Energy
Provides scientific and technical oversight on the activities of implementing organisations.
Suggests policies and strategies on transparency.
The responsible governmental authority is METI, which:
Establishes the Basic Policy.
Establishes the Final Disposal Plan
Calculates fees.
The following laws and regulations govern the disposal of HLW in Japan:
The Specified Radioactive Waste Final Disposal Act (the Act) (2000)
The ordinance on implementing organisations (2000)
The ordinance on financing of and accounting for implementing organisations (2000)
The ordinance on the cost necessary for final disposal (2000)
The notification on the conversion factors for the amount of vitrified waste per amount of thermal generation from spent fuel (2000)
The notification on the organisation responsible for management of the funds (2000)
The notification on the specified securities and financial entities for maintaining the funds (2001)
The Act states that safety regulations for final disposal shall be prescribed by other acts in the future.
</td></tr>
<tr><td>SNF/HLW Management Strategies

National policy and strategy; planned infrastructure;</td><td>
The waste producers have the primary responsibility for safe processing and disposal of waste. The Government is responsible for regulating, and giving guidance to, the producers, thereby ensuring that waste processing and disposal are carried out safely.

Japan has adopted the closed fuel cycle. Currently it is a customer of Cogema and BNFL but all SNF shall eventually be reprocessed domestically.

SNF is sent to reprocessing facilities after a period of on-site cooling and storage. The SNF has been reprocessed in France and the UK, with the exception of a portion reprocessed by the Japanese Tokai Reprocessing Plant. In the meantime, the Rokkasho-mura SNF Reprocessing Plant is being built domestically. The plant is to be completed by 2005. Storage of SNF in the plants' storage facility began in 1999 and export of SNF to foreign reprocessing plants ceased in July 2001.

HLW arising from reprocessing shall be disposed of by geological disposal. Vitrified HLW shall be emplaced in a stable geological formation at a depth of more than 300 m, following 30 to 50 years of
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<tr><th colspan="2">WASTE MANAGEMENT: JAPAN</th></tr>
<tr><td></td><td>interim storage for cooling purposes.

The Basic Policy established by the ministry specifies that the final repository shall have sufficient capacity for more than 40,000 canisters of HLW, corresponding to the amount of SNF generated by 2020. The best host rock in which to locate the repository has not been selected yet.

Japan also pursues research into partitioning and transmutation of HLW because it may contribute to reducing the burden of waste processing and disposal.</td></tr>
<tr><td>Status of Implementation

Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories</td><td>Japan has not decided whether other types of radioactive waste will be disposed of in the HLW repository.

The current time schedule for future SNF and HLW disposal activities looks as follows:
Next couple of years: Selection of preliminary investigation areas.
About 2010: Selection of areas for detailed investigation.
About 2025: Selection of the site for repository construction
About 2035: Start of repository operations
The Japan Nuclear Cycle Development Institute is developing URLs in Tono (sediments), in Horonobe (sedimentary rock), Mizunami (granite), and Kamaishi (granite).

To support site selection, the implementing organisation will conduct characterization of the candidate sites in underground facilities during the detailed investigation stage.</td></tr>
<tr><td>Approaches to Siting

Siting process; current status</td><td>The Act and relevant ordinances specify that the siting process will consist of 3 phases:
Selection of preliminary investigation areas.
Areas to be the subject of preliminary investigations will be selected by conducting literature surveys.
Selection of detailed investigation areas.
Areas to be the subject of detailed investigations will be selected based on a review of the results of the preliminary investigations.
Selection of a site for repository construction.
The site(s) to be developed into a geological repository will be selected based on a review of the results of the detailed investigations.
NUMO has adapted its selection process in order to pursue an open solicitation in which they will ask communities to volunteer to be the subjects of preliminary siting investigations that could then lead on to repository siting. Literature surveys will be performed for the areas from which applications are filed, and preliminary investigation areas will be selected from among the areas that volunteer. Volunteer</td></tr>
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WASTE MANAGEMENT: JAPAN

communities will be financially compensated.

Finance and Economics

Cost estimates for disposal; financing method

The total cost of geological disposal in Japan have been estimated as follows:

Project elements	**Element costs (billion Yen* 2001) Sedimentary rock**	**Granite**
R & D	108.8	108.8
Siting & land acquisition	216.8	241.8
Design & construction	1,037.3	863.7
Repository operation	666.2	764.3
Decommissioning & closure	77.3	86.1
Monitoring	122.6	122.6
Project management	610.7	539.2
Tax	108.9	107.3
Total	**2,948.6**	**2,833.8**

The cost estimates include compensation for the implementing body, but not for regulatory and oversight organizations.

The Radioactive Waste Management Fund was established in 2000 into which financial resources for geological disposal of HLW are to be deposited. The Fund is managed by the Radioactive Waste Management Funding and Research Centre and is maintained externally from the utilities.

An annual fee, which is calculated each year, is to be collected from the nuclear utilities. The amount of fee charged to any particular nuclear power plant depends on the thermal-efficiency of the nuclear power plant. The fee per kW•h in 2001 is approximately 0.13 Yen on average for electricity generated at NPPs. An additional 0.07 Yen per kW•h is charged as a fee for operations prior to establishment of the fund. The Ministry determines the annual fee.

* 1 Yen = 0.012 CAD (2003)

Public Involvement

Approaches at national, state, and community levels

The Act and relevant regulations contain the following requirements pertaining to the role of local governments:

- The implementing organisation is required to submit the report on each phase of the site survey to the governor(s) and mayor(s) concerned for their review and comment upon completion of the report.
- The implementing organisation is required to consider any comments received and submit the revised documents to the governor(s) and mayor(s), including the public comments and the implementing body's responding views.
- METI is required to fully respect the comments made by the governor(s) and mayor(s) when it approves selections of the preliminary investigation areas.

The Act and relevant regulations require that the following steps be taken to provide for public involvement and transparency during repository site selection:

WASTE MANAGEMENT: JAPAN	
	• The implementing organisation must make the report for each phase of site selection available for public inspection and comment in the province(s) involved for one month when the report is completed in each phase. • The implementing organisation is required to organize a meeting with the public in the province(s) involved during the public comment period. During the meeting, the implementing organisation disseminates and explains the results of the report to the public. • Members of the public are allowed to submit their opinions within two weeks after termination of the public inspection and comment period. • The implementing organization must take public opinions into consideration during the site selection process, such as in the selection of a possible area(s) for preliminary investigation. During its launch of the solicitation procedure for volunteer communities, NUMO distributed comprehensive documentation to over 3000 communities and held numerous public meetings.
International Cooperation *Main international partners; major cooperative projects*	Japan plays an active role in projects of OECD/NEA and IAEA. NUMO has quickly established itself as one of the most active waste management organisations when it comes to international cooperation. In the three years since its establishment it has entered into cooperation agreements with most of the other major waste organisations around the world. It has also established an International technical Advisory Committee, with members from 7 different countries. Due to its recent establishment and relatively strong financial backing NUMO is presently contracting for services from many of its sister organisations abroad. Japan participates in URL programs in Belgium, Canada, Sweden, Switzerland, while Switzerland is the only foreign partner in the Japanese URL programs. Japan is a member of the International Association for Environmentally Safe Disposal of Radioactive Materials – EDRAM.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.meti.go.jp (Ministry of Economy, Trade and Industry) www.numo.or.jp (Nuclear Waste Management Organization) www.jnc.go.jp (Japanese Nuclear Cycle Development Institute) www.rwmc.or.jp (Radioactive Waste Management Funding and Research Centre)
Additional Information	Japan is one of the most pro-active nuclear nations, although there has been a significant rise in opposition to nuclear power. TEPCO is the largest private electrical utility in the world. The NUMO volunteer scheme for siting a HLW repository is the most recent and most dramatic national approach to shifting weight from technical to

WASTE MANAGEMENT: JAPAN	
	societal issues in waste disposal. As yet there are no formal volunteer communities although several have requested further information on the process.

WASTE MANAGEMENT: REPUBLIC OF KOREA	
Nuclear Activities *Nuclear power program*	In 2003, 14 light water reactors and 4 heavy water reactors (CANDU) were in operation in the Republic of Korea with 2 additional light water reactors under construction. The reactors in operation have a capacity of about 15,700 MWe and supply some 40% of the national electricity generation. Korea plans to construct and operate 8 new nuclear power units by 2015, resulting in a total energy capacity of about 26,000 MWe.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	Korea operates with two main categories of radioactive waste: • HLW – High Level Waste • LILW – Low and Intermediate Level Waste with maximum allowable radioactivity and heat generation levels both defined. SNF is managed under a chain of responsibility linking the Government to the state-owned giant utility Korea Electric Power Co (KEPCO) and its subsidiary Korea Hydro and Nuclear Power Co (KHNP) As of September 2002, SNF inventories for light water reactors and heavy water reactors were 2,810 tonnes and 2,978 tonnes respectively. The total amount of SNF projected to be unloaded from all reactors by 2040 is 34,000 tonnes.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	Because the Republic of Korea currently does not have concrete programs for disposal of HLW/SNF, an implementing organisation has not been established yet. The regulatory authorities responsible for developing regulations and granting licenses pertaining to SNF/HLW management are • Ministry of Science and Technology (MOST) with its Nuclear Safety Commission (NSC) • Korea Institute of Nuclear Safety (KINS) The oversight body is • Atomic Energy Safety Commission (AESC) On the Government level, the Atomic Energy Commission (AEC) establishes waste management and disposal policies. The Atomic Energy Act (2001.1) specifies the guidelines for radioactive waste management. The Enforcement Decree of the Atomic Energy Act (2001.7) establishes the requirements for implementation of the Atomic

WASTE MANAGEMENT: REPUBLIC OF KOREA	
	Energy Act. More detailed regulations and criteria for disposal of SNF have not been developed yet.
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	A “National Radioactive Waste Management Policy” was set out by the AEC in 1998. The government has the responsibility for the management of radioactive waste. The expenses related to radioactive waste management shall be levied on the radioactive waste generator. Korea is aiming to construct a centralized SNF interim storage facility by 2016 by which time existing at-reactor storage will be exhausted. Korea believes that a deep geological repository is the best solution. There is no siting program in place; the interim storage facilities will keep open the option of treating spent fuel as a strategic reserve rather than a waste. An R&D program was launched in 1997 to establish a reference repository system for disposal of SNF. The basic assumptions used in this program were: • Capacity for 36,000 tonnes SNF ○ 20,000 tonnes from LWRs ○ 16,000 tonnes from HWRs • 500 m underground.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	All nuclear reactors have a SNF pool on-site. Korea is aiming to construct a centralized SNF interim storage facility by 2016. A decision regarding whether this will be a wet or dry storage facility has not yet been taken. During the first stage, the facility will have a capacity of 2,000 tonnes. This will be expanded in stages to a total capacity of 20,000 tonnes. No time schedule for construction and operation of a HLW repository has been proposed yet. There is however an ongoing research program to establish a reference repository system and to assess the feasibility of a deep geological repository. This research program is conducted by the Korean Atomic Energy Research Institute (KAERI) and shall be completed by 2006 Development of an URL will be considered once the KAERI program has been completed. A site-specific URL is considered desirable.
Approaches to Siting *Siting process; current status*	The basic criteria for siting will be developed in the future, with reference to the generic criteria developed by the IAEA and other countries that have had experience in the repository site selection process. The criteria will cover socio-economic aspects, as appropriate, as well as radiological and environmental issues. The

WASTE MANAGEMENT: REPUBLIC OF KOREA	
	technical basis for the repository siting criteria will be proposed by KAERI in 2006 after completion of their long term HLW/SNF disposal research. Based on the KAERI work, KINS will develop the technical criteria, and submit the criteria to MOST for approval.
Finance and Economics *Cost estimates for disposal; financing method*	Republic of Korea is at an early stage of fundamental R&D, and no cost analysis has yet been performed. A financing system has not been established yet.
Public Involvement *Approaches at national, state, and community levels*	The formally approved "National Policy" contains explicit commitments to public involvement. Radioactive waste shall be managed transparently and openly, and the radioactive waste management project shall be promoted in cooperation and harmony with the local community, and keeping abreast with enhancing community development. Sites that will accommodate radioactive waste shall be selected through an open and democratic procedure. Local governments will inevitably be involved in the siting process. Details on how this involvement will be carried out will be considered in the future. A high priority will be given to public involvement and transparency as the program is developed in more detail.
International Cooperation *Main international partners; major cooperative projects*	Korea is considering participating In international URLs in order to build technical capabilities before establishing a development plan for their own site-specific URL.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.kaeri.re.kr (Korean Atomic Energy Research Institute) www.knics.re.kr (Korea Nuclear I&C System R&D Center) www.most.go.kr (Ministry of Science and Technology) www.kepco.co.kr (Korea Electric Power Co)
Additional Information	Korea, with no natural fuel resources, is firmly committed to a nuclear energy policy. Negative experience with trying to site a LLW repository has discouraged Korea from initiating an active HLW repository siting program.

WASTE MANAGEMENT: MEXICO	
Nuclear Activities *Nuclear power program*	In 1976, the construction of the Laguna Verde Nuclear Power Plant (LVNPP) was initiated; comprising two light water reactors of 650 MWe net each. The first unit went into operation in 1990 and the second in 1995. The 1,300 MWe accounts for between five and six percent of the total electricity production. The NPP is owned and operated by the Federal Electricity Commission (CFE). For the time being there are no plans regarding new units or new plants. The national energy program for 2001 to 2006 however, includes the analysis of the long-term introduction of fourth generation reactor designs, considering the possible recycling of SNF from current reactors.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	The Radioactive Waste Classification National Standard classifies waste into • Low Level Waste • Intermediate Level Waste • High Level Waste • Mixed Waste • Uranium and Thorium Tailings US sources give the total amount of SNF in storage as of 2000 as 220 tonnes and predict that 710 tonnes will have been produced by 2020.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	The final disposal of radioactive wastes is the responsibility of the state. A nuclear waste management organisation has not yet been established. The Ministry of Energy is responsible for nuclear fuel cycle policy and operations, and can by law delegate some of these responsibilities to public entities such as the CFE and the National Nuclear Research Institute (ININ). The regulatory body – The National Commission on Nuclear Safety and Safeguards (CNSNS) is in charge of nuclear regulation and safeguards. It is a semi-autonomous body, under the authority of the Ministry of Energy. The Commission is chaired by a representative from the Ministry of Energy and may include representatives of other public bodies as well as experts in the field of nuclear power. Essential legal texts regulating nuclear power are, among others: • The Constitution of Mexico, Article 27 – Nuclear Matters Law (1985) • Law on Third Party Liability for Nuclear Damage • Radiological Safety General Regulations (1988) • General Act on Ecological Balance and Environmental

WASTE MANAGEMENT: MEXICO	
	Protection.
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	Presently there are no activities related to the final disposal of radioactive waste taking place. The only activities authorized in this field are related to the temporary storage of such wastes. SNF from the LVNPP is being stored in the reactor pools, which can accommodate all the SNF that the reactors will produce during their expected lifetime. This gives CFE the time needed to study all possibilities before making a definitive decision regarding the management and disposal of the SNF/HLW. And correspondingly, standards related to HLW management are still to be developed.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	SNF from the LVNPP is presently being stored in the reactor pools. Because Mexico does not yet have any policy on HLW/SNF management strategy, no geological repositories nor any conditioning facilities are currently planned.
Approaches to Siting *Siting process; current status*	Because Mexico does not yet have any policy on HLW/SNF management strategy, no geological repositories are currently planned and hence no siting process has started.
Finance and Economics *Cost estimates for disposal; financing method*	While options for the final disposal of SNF are being looked into, there are no plans or regulations for the financing of this option. The CFE is responsible for the provision of financial resources for the management of radioactive waste from the country's nuclear reactors. Due to the absence of a radioactive waste management program however, the elements for the establishment of rules regarding this provision are inadequate.
Public Involvement *Approaches at national, state, and community levels*	Because Mexico does not yet have any policy on HLW/SNF management strategy, no strategy for public involvement in the disposal process has been developed. The LVNPP has an information centre for visitors, providing information to the public regarding nuclear energy. Also, the Ministry of Energy has a special communication department, which, among other duties, handles inquiries regarding activities related to the handling of radioactive wastes.
International Cooperation *Main international partners; major cooperative projects*	Mexico is a member of the IAEA and the OECD/NEA. Mexico does not have any international partners and does not participate in specific cooperative projects related to HLW/SNF management or disposal. There is an agreement with the USA on exchanging all information on waste activities within 100 km of their common border.

WASTE MANAGEMENT: MEXICO	
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.energia.gob.mx (Ministry of Energy) www.inin.mx (National Institute of Nuclear Research) www.cfe.gob.mx (Federal Electricity commission) www.iie.org.mx (Electric Research Institute)
Additional Information	

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<tr><th colspan="2">WASTE MANAGEMENT: NETHERLANDS</th></tr>
<tr><td>Nuclear Activities

Nuclear power program</td><td>The Netherlands has one light water nuclear power reactor (Borssele) in operation. The capacity is 480 Mwe and it supplies some 4% of the national energy production.

The only other nuclear power reactor in the Netherlands (Dodewaard) was shut down in 1997 and is currently being decommissioned.

The Netherlands plans to close down Borssele by 2004.</td></tr>
<tr><td>Waste Categories and Quantities

Categorisation of radioactive wastes; quantities of SNF and HLW</td><td>The Netherlands operates with the following main waste categories
Low and interim level Waste
In sub categories separating α emitting wastes from β/γ emitting wastes and splitting the latter into wastes with half-lives above and below 15 years.
High Level Wastes
The total amount of SNF and vitrified HLW to be managed after the end of nuclear power in the Netherlands is estimated to be 40 m^3 and 70 m^3, respectively.

Since all SNF from the NPPs will be reprocessed, the volume of SNF to be managed arises from research reactors.</td></tr>
<tr><td>Legal and Regulatory Framework

Implementing and regulatory bodies; advisory groups; main legislative instruments</td><td>The implementing organisation is the Central Organisation for Radioactive Waste COVRA, which is responsible for the implementation of all radioactive waste management, including the storage of HLW.

The nuclear utilities and other waste generators are responsible for maintaining financial resources.

The responsible regulating governmental authorities are:
Ministry of Economic Affairs.
Ministry of Housing, Spatial Planning and Environment.
Ministry of Social Affairs and Employment.
Major laws and regulations applicable to nuclear installations are as follows:
The Nuclear Energy Act (1963)
The Environmental Protection Act (1979)
General Administrative Act (1992)</td></tr>
<tr><td>SNF/HLW Management Strategies

National policy and strategy; planned infrastructure;</td><td>Both of the Dutch NPPs have entered into contracts for reprocessing of their spent fuel. In accordance with these contracts, the HLW resulting from reprocessing will be returned to the Netherlands.

A centralized dry interim storage facility for HLW – HABOG – has been constructed at the COVRA site.</td></tr>
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<tr><th colspan="2">WASTE MANAGEMENT: NETHERLANDS</th></tr>
<tr><td></td><td>There are no concrete plans for a disposal facility for HLW in the Netherlands, although the stored HLW is regarded as being in a form suitable for disposal.

The Netherlands is keeping the door open for participating in a multinational repository.</td></tr>
<tr><td>Status of Implementation

Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories</td><td>The dry interim storage facility HOBAG has been constructed and is ready to use.

The storage is designed to last at least 100 years.</td></tr>
<tr><td>Approaches to Siting

Siting process; current status</td><td>Since there are no concrete plans for disposal of SNF and HLW at the present time, no formal siting process has been defined.

The present activities of COVRA are therefore limited to treatment, conditioning and storage of radioactive waste and spent fuel.

In the past however, more than 25 years ago, research was carried out at a number of candidate sites for a deep geological repository in the northern part of the country to identify suitable salt formations. These studies determined that about 20 sites met the safety criteria for candidate repositories.</td></tr>
<tr><td>Finance and Economics

Cost estimates for disposal; financing method</td><td>At present no concrete plans for a repository exist. The cost given below have been estimated by independent organizations at the request of the Ministry of Economic Affairs to study the costs of waste management activities:

<table>
<tr><th>Cost element Estimated</th><th>cost (million Euro* 1999)</th></tr>
<tr><td>Construction of HABOG</td><td>115</td></tr>
<tr><td>Operation and maintenance during emplacement of waste (10 years)</td><td>27</td></tr>
<tr><td>Operation and maintenance during storage (100 years)</td><td>227</td></tr>
<tr><td>Total storage cost</td><td>369</td></tr>
<tr><td>Repository design and construction</td><td>230–860</td></tr>
<tr><td>50 years retrievability</td><td>90</td></tr>
<tr><td>Total disposal cost</td><td>320–950</td></tr>
</table>

Acquisition of land for a repository and the decommissioning costs of the storage facility have not been taken into account. The costs do not cover expenses for regulatory activities.

The Netherlands requires that all costs associated with radioactive</td></tr>
</table>

WASTE MANAGEMENT: NETHERLANDS	
	waste management be borne by the persons or institutes responsible for the generation of this waste. These costs, which include costs for removal, transport, treatment, conditioning, storage and disposal, are charged to its customers. The generators of HLW/SNF are required to provide the financial resources required to manage the waste, including final disposal. They have committed to finance construction and operation of a storage facility for HLW and SNF (i.e. HABOG), and to maintain financial reserves for waste disposal in the future. The amount of the reserve is calculated using a discounting method based on the assumption of a long term storage period of 140 years and an interest rate of 3.5%. * 1 Euro = 1.61 CAD (2003)
Public Involvement *Approaches at national, state, and community levels*	The Nuclear Energy Act does not include provisions for the involvement of local administrations or members of the public. On the other hand, the Environmental Protection Act will also apply to the siting process. This act states that local governments are involved in the EIA as "involved administrative bodies". Local and provincial governments are also considered to be "competent bodies" for legislations and regulations regarding the land use planning for a proposed repository site.
International Cooperation *Main international partners; major cooperative projects*	The Netherlands participates in the R&D taking place in he Asse URL in Germany.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.minbuza.nl (Ministry of Foreign Affairs) www.nrg-nl.com (Nuclear Research And Consultancy Group)
Additional Information	The Netherlands was the first country to raise the issue of reversibility and waste retrievability to such a prominent position that all work on geological repository siting ceased. Retrievability is currently required by law.

WASTE MANAGEMENT: PAKISTAN	
Nuclear Activities *Nuclear power program*	Pakistan operates one heavy water reactor and one light water reactor with a total capacity of about 450 MWe. They provide some 3% of the national energy supply. Pakistan is planning to build a second light water reactor. Pakistan also has other NFC facilities, like, U-mining and milling, conversion, enrichment and fuel fabrication, but not yet any SNF/HLW disposal program. Pakistan's nuclear strategy has been directed towards independence and self-reliance due to international embargoes.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	Low-, Intermediate- and High Level Wastes are the main waste categories in Pakistan. There are no official documented figures for the expected SNF arising in Pakistan.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	The Pakistan Atomic Energy Commission (PAEC) is responsible for nuclear power project development and implementation. PAEC owns the two Pakistani NPPs and is responsible for their operation and maintenance. PAEC is a public sector company; there is presently no private investment in the nuclear sector. Nuclear regulatory matters are overseen by the Pakistani Nuclear Regulatory Authority (PNRA), which was established in 2001. Transport and Waste Safety Directorate (WSD) at PNRA is responsible to deal with matters related to radioactive waste management. It establishes and maintains a regulatory framework including regulations, requirements and safety guides, and assures compliance with regulatory requirements through regulatory inspections carried out by Regional Directorates and by WSD personnel The main national laws and regulations pertaining to the nuclear power industry are: • Pakistan Nuclear Safety and Radiation Protection Ordinance (1984) • Pakistan Nuclear Safety and Radiation Protection Regulations (1990) • Regulations for Licensing of Nuclear Installation(s) in Pakistan Some regulations are still in draft format: • Regulations on Radioactive Waste management • Regulations for the Safe Transport of Radioactive Materials.

WASTE MANAGEMENT: PAKISTAN	
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	Because it produces weapons materials, Pakistan reprocesses SNF. There is no national waste management strategy documented.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	SNF is stored in pools at the two plant sites. Because Pakistan does not yet have any policy on HLW/SNF management strategy, no geological repositories nor any conditioning facilities are currently planned.
Approaches to Siting *Siting process; current status*	Because Pakistan does not yet have any policy on HLW/SNF management strategy, no geological repositories are currently planned and hence no siting process has started.
Finance and Economics *Cost estimates for disposal; financing method*	No public information available.
Public Involvement *Approaches at national, state, and community levels*	There is no documented strategy for public involvement in the disposal process.
International Cooperation *Main international partners; major cooperative projects*	Pakistan is a member of the IAEA, WANO and COG. Due to its rejection of the 1970 Nuclear Non-Proliferation Treaty (NPT), Pakistan has very little cooperation with other countries in the nuclear area and its nuclear strategy has been directed towards complete independence and self-reliance. Pakistan does not have any international partners and does not participate in cooperative projects related to HLW/SNF management or disposal. The country tries however to attract foreign partners in nuclear power development.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.pnra.gov.pk (Pakistani Nuclear Regulatory Authority)
Additional Information	Being a nuclear weapons state, the line between the military nuclear program and the small civilian nuclear program is hard to establish. Sometimes these programs overlap, which makes it difficult to obtain exact data for the civilian sector.

WASTE MANAGEMENT: ROMANIA	
Nuclear Activities *Nuclear power program*	Romania operates one (CANDU) heavy water reactor with a capacity of 700 MWe, supplying 10% of the national energy. The unit was supplied by AECL and was completed in 1996. Romania intends to complete a second, identical, unit on the same site by 2005. Construction on three additional, identical, heavy water reactors on the same site has been suspended indefinitely.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	Low-, Intermediate- and High Level Wastes are the main waste categories in Romania. US sources give the total amount of SNF in storage as of 2000 as 440 tonnes and predicts that 4,170 tonnes will have been produced by 2020.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	A draft law to be submitted for approval to the Parliament proposes the establishment of a national competent authority for SNF and radioactive waste management (National Radioactive Waste Agency – ANDRAD). The National Research Subsidiary (SCN) has a major research program focused on radioactive waste management. The National Commission for Nuclear Activities Control (CNCAN) – the Nuclear Regulatory Body – is an independent governmental body. CNCAN is the national competent authority in the nuclear field exercising regulation, authorization and control powers with respect to the licensing process of nuclear installations. The Ministry of Education and Research is charged with the coordination of the overall nuclear program. The ministry employs its specialized general division – the National Agency for Atomic Energy (ANEA) – for this task. The Ministry of Industry and Resources is the responsible authority for the planning and coordination of the national nuclear industry activity. All aspects of the nuclear fuel cycle and the operation of nuclear installations are governed by the Romanian Atomic Law: • Law No. 111/1996 (as amended) on the Safe

WASTE MANAGEMENT: ROMANIA	
	Deployment of Nuclear Activities.
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	Romania is in the process of developing a radioactive waste management program. For its SNF, Romania plans for the long-term dry interim storage at the NPP site, with subsequent disposal in either a salt or a hard rock geological formation.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	The SNF storage pool of the operating reactor can accommodate SNF for ten full years of operation. A dry interim SNF storage facility project (DICA) is in progress. It is based on the MACSTOR cask system. The first part of the facility was licensed in 2003. When completed the facility shall have the capacity to store all SNF produced by the two reactors over 50 years. For the final repository, generic survey studies are performed looking for solutions consistent with international practice.
Approaches to Siting *Siting process; current status*	The dry cask storage facility gives Romania time to postpone a final decision on which option to choose for the final disposal of SNF. This time will be used to monitor the progress achieved in other, more advanced countries in this field, and take advantage of the experience gained by other waste management organisations. Hence, no active siting process for a SNF/HLW repository is currently taking place.
Finance and Economics *Cost estimates for disposal; financing method*	The costs of waste management in Romania are not available. There is no overall financial mechanism in place at present. However, it is a requirement of Law 111/1996 (as amended in 1998) that Parliament issues regulations on a fund for the management of radioactive waste and decommissioning. According to the Law, all producers of radioactive waste are obliged to make annual contributions to this fund. For the NPP, this contribution will be covered by a levy added to the price of electricity. So far however, the mechanism for the operation of the fund has not been defined precisely.
Public Involvement *Approaches at national, state, and community levels*	Both the NPP as well as the operator, Nuclearelectrica, have departments for public relations. Their activities presently consist of holding press conferences, the organisation of visits to the NPP, and the periodic distribution of newsletters.

WASTE MANAGEMENT: ROMANIA	
	The public information activities are directed towards the press, politicians, local authorities and schools and universities, in addition to the general public. The activities promote the approaches developed regarding the storage and disposal of radioactive waste and are aimed towards obtaining general acceptance of the chosen solutions.
International Cooperation *Main international partners; major cooperative projects*	Romania is a member of the IAEA.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.mct.ro (Ministry of Education and Research) www.mincom.ro (Ministry of Industry and Resources) www.cncan.ro (Nuclear Regulatory Body)
Additional Information	

<table>
<tr><th colspan="2">WASTE MANAGEMENT: RUSSIAN FEDERATION</th></tr>
<tr><td>Nuclear Activities

Nuclear power program</td><td>At the end of 2001, the Russian Federation had 15 light water reactors, 14 graphite moderated (mainly RBMK) and one FBR in operation. Their total capacity amounts to 22,600 MWe. They supply some 15% of the national electricity production.

Three light water reactors and one RBMK reactor with a total capacity of 4,000 MWe are under construction.

The share of nuclear power in the national electricity production is expected to increase. The Concept of the Nuclear Power Development Program in the Russian Federation assumes that the energy situation will favour large-scale nuclear power development by 2030 with 30-35 % share of total electricity production.

Russia also has all other NFC facilities (U-mining, fuel fabrication, reprocessing), but not yet HLW disposal.</td></tr>
<tr><td>Waste Categories and Quantities

Categorisation of radioactive wastes; quantities of SNF and HLW</td><td>The Russian Federation operates with the following main waste categories

• Low- and Intermediate Level Waste
• High Level Waste

Since Russia is striving for a closed nuclear fuel cycle, SNF is in principle not considered waste although some SNF is, for technical reasons, slated for direct disposal.

There are no available official Russian data on the total quantity of SNF and HLW currently in storage in the Russian Federation available. US sources give the 2000 figure as 26,000 tonnes and the 2020 prediction as 45,000 tonnes.</td></tr>
<tr><td>Legal and Regulatory Framework

Implementing and regulatory bodies; advisory groups; main legislative instruments</td><td>The implementing organization is the Ministry of Atomic Energy, Minatom, through its institutions
• Research and Siting Organization.
• Design Organization.
• Construction and Maintenance Organization.

Minatom also manages all financial resources.

The oversight and regulation function is performed by
• The Federal Nuclear and Radiation Safety Authority (Gosatomnadzor, GAN) of Russia
  ○ Is responsible for nuclear safety regulation and nuclear activities oversight.
• The Ministry of Natural Resources
  ○ Is responsible for environment protection regulation.

On the government level, all nuclear activities are under the</td></tr>
</table>

WASTE MANAGEMENT: RUSSIAN FEDERATION	
	jurisdiction of Minatom, which • Develops policies and strategies for waste management. • Develops and manages the federal waste management programs. • Co-ordinates research activities. • Prepares the budget for waste management. The fundamental institutional framework for radioactive waste management is stipulated in the • Law on Utilization of Atomic Energy (1995) • Law About State Policy in the field of Radioactive Waste Management • Law on Radiation Safety of the Public • Law on Environmental Assessment • Law on Sanitary-Epidemiological Health of the Public.
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	SNF from VVER-440 light water reactors, the BN-600 fast breeder and from nuclear submarines is presently being reprocessed only at the RT-1 reprocessing plant at Mayak (now Ozersk). The reprocessed uranium is recycled as fuel for RBMK reactors while the recovered plutonium is being stored for future use. There are no plans to reprocess RBMK fuel. Formerly Russia disposed of wastes, including HLW, by direct injection into deep boreholes. The Russian policy is now to dispose of HLW in deep mined geological repositories. Minatom also has a policy of importing foreign SNF for storage and reprocessing. Debate continues on the possibility of importing SNF for disposal. The Minister of Minatom has also recently proposed implementation of International Spent Fuel Centres, but deep boreholes disposal is also studied.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	There is a central (wet) storage facility for SNF from the VVER-1000 light water reactors at Krasnoyarsk-26 (now Zheleznogorsk). The storage capacity is 9,000 tonnes. This fuel was originally intended for reprocessing in the RT-2 facility at Krasnoyarsk but construction of RT-2 was stopped. Four facilities in geological formations are planned for storage and disposal of solid and solidified radioactive waste: • Mayak Enterprise o Storage of solidified HLW. • Krasnoyarsk Mining and Chemical Combine o Storage of SNF from VVER 1000 • Priargunski Mine o Disposal of solidified radioactive waste, including waste in glass form. • Novaya Zemlya Archipelago o Storage of SNF that is not subject to reprocessing.

WASTE MANAGEMENT: RUSSIAN FEDERATION	
	According to the current plans, geological disposal will not begin until 2025/2030.
Approaches to Siting *Siting process; current status*	The original concept was to site repositories at the location where reprocessing wastes were produced, namely Ozersk and Zheleznogorsk. These are still the forward options but other sites are also being investigated in the Baltic Shield and also in Krasnokamensk in far East Siberia.
Finance and Economics *Cost estimates for disposal; financing method*	The only relevant available cost estimate is for the project in the Novaya Zemlya archipelago region for long term storage of SNF that is not subject to reprocessing is as follows: Cost of long term storage per assembly of spent nuclear fuel: Starting period (5 years) USD* 25 000 Succeeding years USD 15 000 Since the other projects are still under investigation, no cost estimates have been conducted for them at this time. Cost estimates for a long-term (40 years) storage facility for SNF in Russia have been made in the NPT project. There, the sum of $4 billion has been allocated for the construction, operation and decommissioning of a storage facility for 10,000 tonnes of foreign SNF. Although there are no published cost estimates for long-term SNF management, Russia has accepted returned SNF from Ukraine at a price of USD 370/kg. The Federal Government finances the cost of all radioactive waste management from the federal budget. * 1 USD = 1.32 CAD (2003)
Public Involvement *Approaches at national, state, and community levels*	The expectations from and mechanisms used in conducting public involvement activities in the Russian Federation are evolving. Local authorities become involved in the repository siting process shortly before the construction application is to be submitted to the federal authorities. Local authorities organize public hearings during which the repository design is addressed. Anyone who wishes to participate is allowed to take part in the discussion. The participants usually include individuals from the following categories: • Representatives of scientific and technical groups responsible for designing the repository. • Officials of local authorities responsible for environmental and sanitary-hygienic issues. • Local experts on ecological issues • Journalists. • Individual citizens who have an interest in the issue under discussion.

WASTE MANAGEMENT: RUSSIAN FEDERATION	
	The construction application must include the results of the public discussion.
International Cooperation *Main international partners; major cooperative projects*	In the field of nuclear power development and implementation, Russia presently has cooperation agreements with Canada, China, France, Germany, India, Iran, Italy, Korea, UK, USA, countries of Central and Eastern Europe and the Newly Independent States of the former Soviet Republics. The most active Russian partners are Ukraine and Kazakhstan. Current areas of international cooperation include the handling of radioactive wastes. Because the environmental clean-up problems in Russia are recognised to be major, financial assistance for waste management has been offered by a number of countries: most notably the USA, Japan and the Nordic Countries.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.minatom.ru (Ministry of Atomic Energy) www.kiae.ru (Russian Research Centre - Kurchatov Institute) www.ibrae.ac.ru (Nuclear Safety Institute) www.gan.ru (Regulatory Authority) (Russian only)
Additional Information	Minatom is in charge of both the civilian and the military nuclear programs. Sometimes these areas overlap, which makes it difficult to obtain exact data for the civilian sector.

WASTE MANAGEMENT: SLOVAK REPUBLIC	
Nuclear Activities *Nuclear power program*	Slovakia operates six light water reactors at two plant sites. Their total capacity is about 2,640 MWe and they provide almost 50% of the national electricity production. The construction of two further light water reactors has been suspended. A gas cooled heavy water reactor was in operation between 1972 and 1979.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	The Slovakia waste regulation distinguishes between the following categories of radioactive waste: • Transitional radioactive waste: In other countries sometimes referred to as Very Short Lived Waste. • LILV-SL: Short lived low- and intermediate level radioactive waste. • LILV-LL: Long lived low- and intermediate level radioactive waste. • HLW: High-level radioactive waste. A total of 2,500 tonnes of SNF is expected to be generated by the Slovakian nuclear plants through their operating lifetimes. No decisions have yet been taken on if or when SNF will be declared as waste. Before 1987, 697 light water SNF assemblies were transported back to the fuel supplier in the Soviet Union. All SNF generated by the gas cooled heavy water reactor has been transported back to the fuel supplier in the Soviet Union (later the Russian Federation). None of the HLW from reprocessing has been or will be returned to Slovakia.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	Since the only owner/operator of nuclear facilities (including SNF and radioactive waste management facilities) in Slovakia is Slovak Electric Plc (a 100% state owned joint stock company), Slovak Electric Plc is the implementing organisation for radioactive waste management and disposal activities, including development of a deep geological repository. There is no national waste agency. The Ministry of National Economy manages the decommissioning, SNF and radioactive waste management fund. The Nuclear Regulatory Authority of Slovakia (UDJSR) is responsible for supervision of nuclear safety (including all aspects of radioactive waste management), the Ministry of Health is responsible

WASTE MANAGEMENT: SLOVAK REPUBLIC	
	for radiation protection regulations, and the State Fund Board is responsible for providing advice to the minister of National Economy regarding expenditures by the implementing body. The UJDSR and the Ministry of Health perform the oversight function. The basic requirements for safe management of radioactive waste and SNF and the general requirements applicable to radioactive waste generators and waste/SNF management facility operators is specified in Act No. 130/1998 on Peaceful Use of Atomic Energy (the Atomic Act).
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	In 2000 the Slovak government adopted the Power Policy of Slovakia that also relates to the concept of fuel cycle back end. The current basic concept for SNF management can be characterized as follows: • Slovakia adopts an open fuel cycle • Transport of SNF abroad followed by import of the reprocessed products into Slovakia is not considered. • The possible transport of SNF abroad for final disposal or for reprocessing without importing any of the reprocessed products back into Slovakia is considered. • In the future, to investigate the possibility of international or regional solutions regarding the final disposal of SNF and to follow development of new technologies in the area of SNF management. Although the government of Slovakia has not yet established a final policy on the management of HLW/SNF, it was decided to continue studying a repository for HLW/SNF. The need for a repository was mentioned in the “State Plan of Geological Research and Investigation” (prepared by the Geological Section of the Ministry of the Environment) and in the “State Energy Policy” (prepared by the Ministry of National Economy), both of which have been approved by the government.

WASTE MANAGEMENT: SLOVAK REPUBLIC	
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	Short-term storage of SNF (3 to 7 years after it has been removed from the reactor core) is assured in the pools installed at each reactor unit. An interim SNF storage facility is in operation at the oldest NPP site since 1987. The SNF is stored inside containers located under water in the individual pools. A corresponding interim SNF storage facility at the newer NPP site is in the planning stage. A Slovakian repository must have sufficient capacity to dispose of all the waste mentioned above. The characteristics of the repository would be • Capacity for approximately 2,500 tonnes SNF. • Crystalline rock formation (e.g. granite) or sedimentary rock formation (e.g. clay) as host rock. • A depth of more than 500 m for crystalline rock, or 200-300 m for sedimentary rock. • Engineered barrier system consisting of container and sealing materials. Slovakia also plans to dispose of a small volume of institutional wastes, mainly spent sealed sources which cannot be disposed of in a near surface repository along with the HLW/SNF. The time-schedule for waste disposal (a national deep repository option) was described in a recent feasibility study carried out for the purpose of planning the State Fund as follows: • 2006-2010: Final governmental decision on the back-end of the nuclear fuel cycle and HLW/SNF management. • 2030: Construction license. • 2030-2050: Repository construction. • 2037: Operating license. • 2037-2095: Operation. • 2095-2102: Repository closure. The necessity for an underground research laboratory will be studied in the course of the siting process.
Approaches to Siting *Siting process; current status*	Siting activities have been carried out since 1997, based on the “Slovak Deep Geological Repository Program”. The main course of the Slovak repository development program has been a preliminary site selection using archive data and maps, conducted by the Geological Survey of Slovakia. This effort resulted in the selection of six sites, with the areas of tens of square kilometres each, as preliminary suitable areas. Then in situ geophysical investigations (e.g. boreholes) were initiated to identify areas suitable for further investigation. These investigations will continue for the next five years to narrow the number of suitable sites.

WASTE MANAGEMENT: SLOVAK REPUBLIC	
	The strategic governmental decision concerning how to close the back end of the nuclear fuel cycle, including geological repository development, must be accomplished through use of a Strategic Environmental Impact Assessment (SEIA), as required by the Act on Environmental Impact Assessment (Act on EIA). The final selection from among the last siting alternatives will be the subject of a standard EIA process. A set of criteria for the preliminary site selection has been developed by the research coordination organization DECOM Slovakia Ltd, with the assistance of the Geological Survey of Slovakia, under a contract with Slovak Electric Plc. In the course of review currently underway, socio-economic aspects and consistency with siting criteria under consideration by the IAEA and European countries are also being considered.
Finance and Economics *Cost estimates for disposal; financing method*	The total cost estimate of managing the SNF and HLW and its breakdown are as follows: **Cost element** — **Cost million SKK* (2000)** Long term storage of SNF for 50 years (from present to 2037) — 15,600 R&D — 8,215 Public relations — 200 Design — 900 Construction (2030–2060) — 20,210 Packaging of wastes (2037–2095) — 10,500 Operation (2037–2095) — 16,300 Closure of underground facilities (2057–2095) — 2,660 Final closure (2095–2102) — 600 **Total** — **~75,200** For the financing of decommissioning of nuclear installations and the management of spent fuel and radioactive waste from decommissioning, a State Fund for Decommissioning of Nuclear Facilities and Nuclear Spent Fuel and Radioactive Waste Management was created. The Ministry of National Economy is responsible for the management of the Fund. Contributions to the Fund are collected at the level of 6.8% of the selling price of electricity produced in nuclear power plants and 350,000 SKK 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 SKK/kW•h. * 1 SKK = 0.04 CAD (2003)
Public Involvement *Approaches at national, state, and community levels*	There has not been any public involvement in the siting process up to now. However, according to the Act on EIA the affected municipalities will be involved in the siting process so that they can make their opinions known and have them considered in the government's decision-

WASTE MANAGEMENT: SLOVAK REPUBLIC	
	making progress, and the public will be allowed to participate in the EIA through public hearings. A progress report on the Slovak Deep Geological Repository Program is prepared every year by DECOM Slovakia, the repository program coordinating company, and sent to Slovak Electric Plc to use in providing information to the public. Plans are under preparation within the repository development program for additional future public involvement activities.
International Cooperation *Main international partners; major cooperative projects*	The Slovak Republic cooperates closely with the Czech Republic and with other Central European Countries. The Decom company in Slovakia is coordinator for the EC study on Regional repositories in Europe.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.ujd.gov.sk (Nuclear Regulatory Authority) www.decom.sk (Decom company)
Additional Information	

<table>
<tr><th colspan="2">WASTE MANAGEMENT: SPAIN</th></tr>
<tr><td>Nuclear Activities

Nuclear power program</td><td>Nine light water nuclear power reactors were put into operation in Spain between 1968 and 1988.
The nine reactors supply some 28 % of the national electricity production. Their total capacity amounts to about 7,800 MWe.

The government decided in 1999 that the existing nuclear reactors will operate for a 40-year lifetime.

There is no plan to construct any new power reactors.

In addition to the above reactors, a 460 MWe graphite-gas reactor is currently being dismantled.</td></tr>
<tr><td>Waste Categories and Quantities

Categorisation of radioactive wastes; quantities of SNF and HLW</td><td>Spain operates with the following main waste categories:
• VLLW-SL – Short-lived Very Low Level Waste
• VLLW-LL – Long-lived Very Low Level Waste
• LILW-SL – Short-lived Low and Intermediate Level Waste
• LILW-LL – Long-lived Low and Intermediate Level Waste
• HLW – High Level Waste

About 2,700 tonnes of SNF are being stored in the Spanish reactor pools at the end of 2001.

Spain will shut down all of its nine reactors after they have reached a lifetime of 40 years. The corresponding total amount of SNF to be disposed of will be about 6,750 tonnes.

Spain also has some 80 m^3 vitrified HLW from earlier reprocessing.</td></tr>
<tr><td>Legal and Regulatory Framework

Implementing and regulatory bodies; advisory groups; main legislative instruments</td><td>The implementing organisation is the National Waste Management Company ENRESA, which
• is responsible for implementation of radioactive waste and SNF management.
• is responsible for Fund management.
• calculates fees.

In addition, an Oversight and Control Committee develops criteria for management and maintenance of the Fund.

The regulatory authority is the Nuclear Safety Council CSN, which
• develops safety guidelines.
• issues binding reports used as the basis for granting licenses.

The responsible governmental authorities are:
• Ministry of the Economy
    ○ Grants licenses for construction, operation, etc.
    ○ Maintains the national policy for management of radioactive waste through annual revision of the</td></tr>
</table>

WASTE MANAGEMENT: SPAIN	
	General Radioactive Waste Plan. o Controls ENRESA's compliance with the policy define din the approved Plan. o Controls the management of the Fund. • Ministry of the Environment o Reviews and approves environmental impact assessments. Major laws and regulations applicable to the management of HLW and SNF are as follows: • Act 25/1964 on Nuclear Energy • Act 15/1980 on the establishment of CSN • Act 54/1997 on the Electricity Industry • Royal Decree 1522/1984 on the establishment of ENRESA. • Royal Decree 1899/1984 developing the functions of ENRESA. • Royal Decree 1836/1999 regulations on nuclear and radioactive installations. • Royal Decree 404/1996 developing Act 40/1994 and modifying R.D. 1522/1984.
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	In 1983, the government adopted an open fuel cycle policy. However, in the past, some SNF was reprocessed abroad resulting in some vitrified HLW. A suitable deep geological formation is considered the best solution for SNF/HLW disposal. However, in parallel, a separate research program looking into the use of new technologies such as separation and transmutation is ongoing. Conceptual non-site specific repository designs have been developed by ENRESA for three candidate host rocks (clay, granite and salt) to provide a basis for R&D activities. The primary characteristics of these potential repositories are as follows: • Capacity for about 7,000 tonnes SNF. • 250 m depth for clay, 500 m depth for granite and 600 m depth for salt. • Engineered barriers will consist of carbon steel canisters and a buffer material out of bentonite clay for the clay and granite options, and salt briquettes for the salt option. Interim storage of the SNF is based on the following stepwise approach: • To take maximum advantage of the space existing in the NPP pools. • Complementing the storage capacity of the pools with dry storage technologies until such time as a centralized interim storage facility is available. • Construction of a centralized storage facility for SNF and

WASTE MANAGEMENT: SPAIN	
	HLW when it is returned from abroad.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	All NPPs have pools for their SNF. One NPP has already constructed an on-site dry storage facility because the spent fuel pool is reaching its capacity limit. The current Spanish strategy is to have a centralized temporary storage facility available by the year 2010 and to postpone the decision regarding the definitive management of SNF and HLW until 2010 as well. For planning purposes, the Spanish disposal facility could begin operation by 2035. Use of an eventual HLW repository for long-lived LILW is also being considered.
Approaches to Siting *Siting process; current status*	A siting process was initiated by ENRESA in 1986. It was defined as a stepwise, systematic screening process designed to gradually narrow down the area in four stages. The first two stages, 1986-1990 and 1990-1995, were completed resulting in the identification of a set of favourable areas for a deep geological repository. The third stage, aiming at the definite selection of suitable sites was interrupted in 1997. It was decided to postpone until 2010 any decisions regarding the definitive management of SNF and HLW, hence no further site selection activities will be carried out for the time being. The previous siting process identified a sufficient number of areas on the national territory as being valid, from a geological point of view, to host a deep geological disposal facility.
Finance and Economics *Cost estimates for disposal; financing method*	The estimated total cost of radioactive waste management activities is about 10,000 million Euro*. The breakdown of the estimated total cost in the period 1985-2065 are as follows: LILW management 16% SNF/HLW management 57% Decommissioning 24% Others 3% The cost estimate includes investments, general expenses of ENRESA; costs associated with reprocessing of spent fuel, disposal of spent fuel and high level wastes, and the costs of corresponding activities for other technologies About 5,589 million Euro is considered as costs related to SNF and HLW management. In accordance with the Spanish legislation, a Fund was established in 1983 to cover the costs of radioactive waste management and decommissioning of nuclear installations, for which ENRESA is

WASTE MANAGEMENT: SPAIN	
	responsible. A system of advance payments has been established to finance the management of radioactive waste from electricity producers. The cost is reflected in a levy on electricity sales and is thereby transferred direct to the final consumer, establishing a mechanism for payment at the moment at which the electricity is consumed. In 2000, the levy on the electricity rate was set at 0.8% of electricity rate. ENRESA calculates the fee every year in the proposed Radioactive Waste Plan, which must be approved by the government. * 1 Euro = 1.61 CAD (2003)
Public Involvement *Approaches at national, state, and community levels*	No public involvement measures were taken during the siting process performed by ENRESA between 1986 and 1997. The role of local governments and the general public in a new siting process will be established after the option for the SNF management has been decided upon by parliament in about 2010. In 1998 ENRESA started promoting visits by the public to ENRESA's facilities, organizing orientation sessions for professionals, distributing information materials, etc. In addition, the four information centres in the country intensified their functions by providing more materials, organizing seminars for teachers and community leaders, etc.
International Cooperation *Main international partners; major cooperative projects*	Spain plays an active role in projects of the EU, the NEA and IAEA. In this connection, the central role that the national waste management organisation – ENRESA – has played within the European Cassiopee consortium, see chapter 3.1.4, is worth a special mention. ENRESA also participated in a total of 37 projects within the 5th EU Framework Programme, and plans to invest a similar amount of effort in the upcoming 6th Programme. ENRESA was the successful bidder for advisory services to the Hungarian PURAM in developing a policy for the management of high-level and/or long-lived radioactive waste and SNF in that country. Spanish proposals for a rock laboratory in granite near the Portuguese border were dropped because of public opposition. Today, Spain has no national URL but is an active participant in most other European URL projects, most significantly in Grimsel and Mt. Terri in Switzerland, Äspö in Sweden and Bure in France. Spain is a member of the International Association for Environmentally Safe Disposal of Radioactive Materials – EDRAM, see chapter 3.1.4.

WASTE MANAGEMENT: SPAIN	
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.enresa.es (National Waste Management Company) www.csn.es (Nuclear Safety Council (Regulators))
Additional Information	

<table>
<tr><th colspan="2">WASTE MANAGEMENT: SWEDEN</th></tr>
<tr><td>Nuclear Activities

Nuclear power program</td><td>A total of twelve light water nuclear power reactors were put into operation in Sweden between 1972 and 1985. One of these, Barsebeck-1, was closed down in 1999 for political reasons. The eleven remaining reactors are operated by four utilities and supply almost 50 % of the national electricity production. Their total capacity amounts to about 9,600 MWe. In 1980, Sweden made the political decision, by a national referendum, to phase out nuclear energy. The original deadline of 2010 for the shut down will not be met.</td></tr>
<tr><td>Waste Categories and Quantities

Categorisation of radioactive wastes; quantities of SNF and HLW</td><td>Sweden operates with the following waste categories
VLLW-SL – Short lived very low level waste.
This waste is disposed of in shallow land fills at the NPPs.
LILW-SL – Short lived low and intermediate level waste.
This waste is disposed of in an existing repository, SFR-1, near the Forsmark NPP.
LILW-LL – Long lived low and intermediate level waste.
This waste will be disposed of in a future, to be sited and decided upon, repository.
SNF – Spent nuclear fuel.
This waste will be disposed of in a future, to be sited and decided upon, repository.
Approximately 300 tonnes of SNF are generated every year. At the end of 2002, more than 4,000 tonnes of SNF had been discharged from the Swedish nuclear power plants, out of which 3,900 tonnes was being stored in the Swedish central storage facility CLAB. The exact amount of SNF to be accumulated before nuclear energy has been phased out is hard to estimate, but an average reactor life expectancy of 40 years will result in up to 9,000 tonnes of SNF. Sweden has only very small quantities of other HLW.</td></tr>
<tr><td>Legal and Regulatory Framework

Implementing and regulatory bodies; advisory groups; main legislative instruments</td><td>The implementing organisation is the Swedish Nuclear Fuel and Waste Management Co. (SKB). SKB is jointly owned by the nuclear power plant operators and is responsible for implementing any activity needed to develop, site construct and operate facilities for disposal of nuclear waste, including SNF. It also handles the development of the nuclear industry’s R&D programs and cost calculations.

Authorities responsible for enforcing compliance with the legislation are:
the Swedish Nuclear Power Inspectorate (SKI), and
the Swedish Radiation Protection Authority (SSI).
SKI together with the Board of the Nuclear Waste Fund is responsible for the fund management.</td></tr>
</table>

WASTE MANAGEMENT: SWEDEN	
	The National Council for Nuclear Waste (KASAM) is an independent advisory body to the Government. The responsible governmental authority is the Ministry of the Environment: • Makes the final decision on licensing of major nuclear installations and on the nuclear industry's R&D programs for waste management. The management of spent fuel and nuclear waste is regulated by a series of statutory provisions, of which the three main legislative instruments are: • The Act on Nuclear Activities (1984:3), • The Radiation Protection Act (1988:220) • The Act on the Financing of Future Expenses for Spent Nuclear Fuel etc. (1992:1537).
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	In 1980, Sweden made the political decision, by a national referendum, to phase out nuclear energy. The current policy regarding the management of spent nuclear fuel was established in the late 1970's, and aims at direct disposal of SNF in a geological formation in Sweden. The reprocessing option that was favoured early in the nuclear program was dropped, primarily for economic reasons. Sweden plans to build one deep geological repository for disposal of SNF. The primary design parameters are: • Capacity for up to 9,000 tonnes SNF • Host rock is crystalline • 400-700 m underground • Engineered barriers consist of copper canisters with cast iron inserts and bentonite clay as buffer material in individual deposition holes. Interim storage of the SNF will take place in a centralized, underground, wet (pool) type storage facility, also with capacity for up to 9,000 tonnes of SNF.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	The system for management of radioactive waste currently consists of • a ship based transportation system, • a final repository for low and medium level waste (SFR) at Forsmark, and • a central interim storage facility for spent nuclear fuel (CLAB) at Oskarshamn, The two main facilities still to be designed, sited, constructed and licensed for SNF are • an encapsulation plant for SNF, and • the SNF repository.

WASTE MANAGEMENT: SWEDEN	
	The present idea is to site the encapsulation plant adjacent to CLAB, the most likely alternative would be to locate it next to the repository. The site decision for the encapsulation plant shall fall in 2005, with operation starting in 2014. The site decision for the SNF repository shall fall in 2007, with operation starting in 2015. Sweden, with international cooperation, operated one of the first underground rock labs at Stripa and now operates the Äspö underground laboratory.
Approaches to Siting *Siting process; current status*	Feasibility studies for siting of the deep repository were carried out in eight municipalities, three were proposed as candidate sites. After voting in the community councils two sites decided to accept site investigations The fieldwork programs for the site investigations are now well into their second year at Forsmark and Simpevarp, both close to nuclear power plants.
Finance and Economics *Cost estimates for disposal; financing method*	The cost of the complete waste management program is estimated to be 45,117 million Swedish Kroner (MSEK*) (undiscounted). These cost estimates are based on plans for the time period from 2001 to 2065 and at a price level of January 2001. According to these figures, the cost for disposal of SNF is estimated at about 28,000 MSEK. For the compensation of the regulatory bodies, an additional amount of approx. 2,000 MSEK is be added to the total estimate. Other costs, such as financial assistance to local communities, are not of any significant level, but it may be worth mentioning that, during the last few years, the contributions given to municipals for information measures have ranged from 8 to 15 MSEK per annum. The nuclear power plants currently pay SEK 0.005 per kilowatt-hour for waste management. The Nuclear Waste Fund administers these funds to finance waste handling. Every year, SKB calculates the total cost of the interim storage of fuel, and the localisation and construction of the final storage facility, the canister plant and the encapsulation plant, as well as the demolition of the nuclear power plants. The Swedish Nuclear Power Inspectorate (SKI) audits SKB's accounts every year and suggests an appropriate fee to the Government, who then decide the fee per kW•h of electricity generated at each NPP. Overall, the nuclear power plants pay approximately SEK 350 million per annum to the Nuclear Waste Fund. * 1 SEK = 0.18 CAD (2003)
Public Involvement *Approaches at national, state,*	The EIA process ensures public input to all major development projects. In municipalities where major nuclear facilities are located, so-called local safety boards are established. Both SKB and SKI

WASTE MANAGEMENT: SWEDEN	
and community levels	have active programs for interacting with the public. Various special projects for this purpose have been initiated (DIALOGUE; RISCOM). Visits to facilities and exhibitions aboard the transport ship Sigyn are valuable mechanisms.
International Cooperation *Main international partners; major cooperative projects*	Sweden plays an active role in projects of the EU, the NEA and IAEA. SKB works very closely with its Finnish sister, Posiva, and has bilateral cooperative agreements with several organizations in the EU, as well as with Japan, Switzerland, the USA and Canada. In addition SKB manages international collaborative work in its Äspö underground hard rock research laboratory. Since the early 1990s, SKB has assisted countries where serious environmental problems due to radioactive waste exist. This is particularly true of the Baltic States and Russia. Partly as a result of this assistance, SKB formed the subsidiary SKB International Consultants (SKB IC) a few years ago to deal with assignments in this area. Since its foundation SKB IC has worked on assignments in Austria, Estonia, Finland, France, Germany, Japan, Kazakhstan, Lithuania, Russia, South Korea and Switzerland. Sweden is a member of the International Association for Environmentally Safe Disposal of Radioactive Materials – EDRAM.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.skb.se (Nuclear Fuel and Waste Management Company) www.ssi.se (Radiation Protection Authority) www.ski.se (Nuclear Power Inspectorate)
Additional Information	Sweden, with its neighbour, Finland, is recognised to be amongst the world's leading countries in radioactive waste management. The early “Stipulation Act” in Sweden, making continued use of the nuclear power dependent on demonstration of safe disposal methods, stimulated pioneering work that established Sweden’s position. Worthy of special mention is the advanced level of encapsulation technology for SNF developed by Sweden together with Finland.

<table>
<tr><th colspan="2">WASTE MANAGEMENT: SWITZERLAND</th></tr>
<tr><td>Nuclear Activities

Nuclear power program</td><td>A total of five light water nuclear power reactors were put into operation in Switzerland between 1969 and 1984. They supply some 40 % of the national electricity production. Their total capacity amounts to about 3,200 MWe. In 2003 a national referendum confirmed that a large majority of the Swiss population was not in favour of shutting down the nuclear program.</td></tr>
<tr><td>Waste Categories and Quantities

Categorisation of radioactive wastes; quantities of SNF and HLW</td><td>Switzerland operates with the following waste categories
SMA – Short lived low and intermediate level waste.
LMA – Long-lived intermediate level waste.
HAA – High-level waste.
A total of about 3,000 tonnes of SNF is expected to be generated by the end of the lifetime of the five Swiss NPPs, assuming a 40-year operational lifetime. Extended lifetimes of 50-60 years are being considered.

About 1,200 tonnes SNF are to be reprocessed resulting in 130 m^3 of HLW, or 1,000 m^3 including overpacks.

The remaining 1,800 tonnes of SNF, equivalent to 5,000 m^3 including overpacks, are planned for direct disposal.</td></tr>
<tr><td>Legal and Regulatory Framework

Implementing and regulatory bodies; advisory groups; main legislative instruments</td><td>Implementing Organisations
Nagra – National Cooperative for the Disposal of Radioactive Waste.
Is responsible for disposal facility preparatory work.
ZWILAG
Is responsible for treatment and storage of radioactive waste and spent fuel.
For construction and operation of specific repositories, dedicated companies will be implemented
The Management Committee for the Waste Management Fund is responsible for managing accumulated financial resources.

Regulatory Authorities
BFE – Federal Office of Energy.
HSK – Federal Nuclear Safety Inspectorate.
BAG – Federal Office of Public Health
Oversight Body
KSA – Federal Nuclear Safety Commission
Governmental Advisory Bodies
AGNEB – Interdepartmental Working Group on Radioactive Waste Management.
KNE – Geological Commission on Radioactive Waste Disposal.</td></tr>
</table>

WASTE MANAGEMENT: SWITZERLAND	
	• EKRA - Regulatory Control of Radioactive Waste Management (now disbanded) The responsible governmental authority is the Federal Department of the Environment, Transport, Energy and Communication: • Establishes policies. • Grants licenses. • Sets fees. The requirements for the safety and financing systems for radioactive waste management are specified, along with requirements for other nuclear activities, in the following laws: • The Nuclear Energy Act (2003) • The Atomic Energy Act (1959) • Federal Decree on the Atomic Energy Act (1978) • The Radiological Protection Act (1991).
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	Switzerland is considering construction of a national repository for disposal of SNF, HLW and TRU in a deep geological formation in Northern Switzerland. The TRU will go in different tunnels from the SNF and HLW. The primary design parameters for the deep geological repository are: • Capacity for approx 660 canisters HLW and approx 1,200 canisters of SNF • Host rock is opalinus clay • 650 m underground • Engineered barriers consist of steel canisters and bentonite clay as buffer material in individual deposition holes. Interim storage of the HLW will take place in a centralized, aboveground, dry type storage facility. Interim storage of the SNF will take place in various wet and dry, centralized and site specific facilities. It is the official Swiss policy to keep the door open for a multinational repository.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	The system for management of SNF and HLW currently consists of • a road and rail based transportation system, • a centralized dry interim storage facility for HLW and SNF (ZZL) owned by ZWILAG, operating since 2001, and • a dry interim storage facility (ZWIBEZ) at the Beznau NPP, licensed but not commissioned to begin storage yet. The two main facilities to be constructed and licensed are

WASTE MANAGEMENT: SWITZERLAND	
	• a wet storage facility at the Gösgen NPP, and • the SNF and HLW repository. The Swiss plans for a national repository call for issuing the required licenses to allow the repository to commence operation between 2040/2050. With a 40-year operating lifetime for the NPPs, and a minimum of 40 year SNF and/or HLW cooling period prior to emplacement, the repository will be required to operate until 2065. Nagra operates the Grimsel Test Site (granite) at 450 meters depth in cooperation with the Czech Republic, France, Germany, Japan, Spain, Sweden and USA. The Federal Office of Water and Geology directs the international Mont Terri Rock Laboratory for Opalinous Clay in cooperation with Belgium, France, Germany, Japan and Spain.
Approaches to Siting *Siting process; current status*	Desk studies conducted in the late 1970s covered all areas of Switzerland, including a very wide range of potential host rocks. Due to the ongoing uplift of the alpine regions of the country, the potential siting areas are less extensive than in most countries. Nevertheless, the wide range of geological formations offers several candidates for potential host rocks. The ongoing siting work is based on a three-phase strategy that was conceived at the beginning of the 1980s. Phase I: Regional studies based on widespread borehole data, as well as extensive measurements from the surface. Phase II: More intensive investigations to examine the siting potential of smaller areas, selected from the best locations identified during Phase I. Phase III: Deep underground exploration and full characterisation of a candidate site. Extensive fieldwork has been carried out in crystalline rocks and in sediments in the Northern part of Switzerland. The option currently favoured by Nagra for a national HLW/SNF repository is in opalinus clay in the region between Zurich and Germany. At the end of 2002 Nagra submitted a major report to the Government recommending that future work should be concentrated in this region.
Finance and Economics *Cost estimates for disposal; financing method*	The table below shows the provisional results of the 2001 cost study for the HLW/long-lived ILW repository. The study assumes an operational lifetime for the nuclear power plants of 40 years, resulting in approximately 3,000 tonnes spent fuel.

WASTE MANAGEMENT: SWITZERLAND	
	The cost estimate takes into account all expenditure associated with geological disposal. It includes all costs incurred to date and thus covers the period since the founding of Nagra up to the closure of the HLW/long-lived ILW repository and the subsequent monitoring phase. Not included in the costs are costs of transport, reprocessing, interim storage and later decommissioning of the nuclear power plants. Costs for HAA/LMA Repository (million CHF*) • Preparatory work 800 • Site characterization, construction 1,100 • Total up to start of operation 1,900 • Operation (excluding spent fuel conditioning) 600 • Closure 400 • Total from start of operation 1,000 • Compensation 500 • Total for disposal 3,400 • Spent fuel conditioning 1,000 • Grand total 4,400 The waste management provisions required during plant operation are accrued in-house by NPP operators and paid for expenditures related to spent fuel reprocessing and interim storage of spent fuel and radioactive waste, as well as to research and development, planning and geological investigations. The waste management provisions required after final shut-down of the NPPs are accrued in a federally controlled Waste Management Fund. These financial provisions are composed of fees collected annually from the NPP operators and paid to the fund during the operating lifetime of the NPPs. The fee is not calculated on a per kW•h basis. * 1 CHF = 1 CAD (2003)
Public Involvement *Approaches at national, state, and community levels*	Due to the formal public involvement process required by legislation, the government organises constructive dialogues between the various stakeholders. When siting field surveys are conducted, a special committee is established to investigate whether all required conditions for the relevant license are fulfilled. A representative of local opponent groups is usually included in this committee. Nagra promotes a two-way flow of information by maintaining direct contact and discussions with all levels of society in the country. Guided tours, open days and visits of groups to investigation sites or URLs are being organised.
International Cooperation *Main international partners;*	Switzerland plays an active role in projects of NEA and IAEA. In addition Swiss institutions manage international collaborative work in the Grimsel and Mont Terri URLs. Among foreign URL projects,

WASTE MANAGEMENT: SWITZERLAND	
major cooperative projects	Switzerland is most heavily involved in the Äspö hard rock laboratory in Sweden and the Bure indurated clay facility in France. The national waste organisation Nagra has bilateral cooperative agreements with several organizations in the EU, as well as in Canada, Japan and USA. Switzerland is a member of the International Association for Environmentally Safe Disposal of Radioactive Materials – EDRAM, and the Swiss utilities support the activities of ARIUS, the Association for Regional and International Underground Storage, see chapter 3.1.4.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.hsk.psi.ch (Federal Nuclear Safety Inspectorate) www.nagra.ch (National Cooperative for the Disposal of Radioactive Waste) www.zwilag.ch (Company responsible for treatment and storage of radioactive waste and SNF).
Additional Information	

WASTE MANAGEMENT: UK	
Nuclear Activities *Nuclear power program*	In 2003, 30 gas cooled reactors and one light water reactor were in operation in the UK while 12 nuclear reactors had been taken out of service. The reactors in operation have a capacity of about 13,000 MWe (1999 data) and supply some 23% of the national energy production. There are no concrete plans to phase out nuclear power in the UK. On the other hand, there are no concrete plans for new nuclear power stations.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	The UK operates with the following main waste categories • VLLW – Very Low Level Waste • LLW – Low Level Waste • ILW –Intermediate Level Waste • HLW – High Level Waste Spent fuel is not categorized as waste. At the end of 2001, there were about 1,600 m^3 of non-conditioned and 340 m^3 of conditioned HLW in storage in the UK. It is estimated that the UK will accumulate a total of 1,520 m^3 of conditioned HLW from existing facilities until end of life.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	The United Kingdom does not have a policy on disposal of HLW. As a consequence, an implementing organisation responsible for HLW disposal has not been established. The organisation, NIREX, formed to implement a LLW/ILW repository, studies some aspects of HLW disposal, as does the Government Environmental Agency. The owners of SNF and HLW are responsible for maintaining financial resources to fund waste management. The regulatory/oversight bodies responsible for nuclear safety regulation for waste disposal are • The Environmental Agency in England and Wales. • The Scottish Environmental Protection Agency (SEPA) in Scotland. • The Environment & Heritage Service in Northern Ireland. In addition to the Environmental agencies, the Nuclear Installations Inspectorate (NII) oversees storage of HLW. On the Government level, the Department for Environment, Food and Rural Affairs (DEFRA) establishes policies on radioactive waste management.

WASTE MANAGEMENT: UK	
	In the absence of a HLW disposal policy, there are no particular laws and regulations on disposal of HLW. The Radioactive Waste Management Advisory Committee (RWMAC) is a governmentally appointed advisory body concerned with all major radioactive waste management issues. In 2003 a new advisory group CORWM was formed.
SNF/HLW Management Strategies *National policy and strategy; planned infrastructure;*	The United Kingdom currently has a policy which calls for above ground storage of vitrified HLW for at least 50 years. For many years Governmental policy was to implement a HLW repository some 100 years in the future. Following the collapse of the UK LILW repository project at Sellafield, all options for long term management of radioactive wastes were re-opened for consideration. Accordingly, today, the UK does not have a policy on disposal of HLW or on long-term waste management. SNF is not classified as HLW.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	Since the UK has not yet decided which option (e.g. storage or disposal of HLW and SNF) to adopt, it does not currently have any concrete concept or any time schedule for an eventual repository for HLW and SNF.
Approaches to Siting *Siting process; current status*	Since the UK has not yet decided which option (e.g. storage or disposal of HLW and SNF) to adopt, it does not currently have a policy for the siting process or siting criteria. In the 1980s many siting options were examined and field-work in crystalline rocks in Scotland undertaken. The program was aborted due to public opposition.
Finance and Economics *Cost estimates for disposal; financing method*	Since the United Kingdom has not yet decided which option (e.g. storage or disposal of HLW and SNF) to adopt, it is not able to estimate the cost for disposal of HLW and SNF. However, a government financial review of Nirex's proposals for a deep disposal repository referred to an overall industry waste management figure in relation to nuclear waste in the order of £* 20 billion of which roughly 15% can be attributed to the capital and operating costs of the Nirex disposal program. This is consistent with the UK government's nuclear review document (published in 1995) which quotes a gross lifetime cost of discharging nuclear facilities (including both decommissioning and management of spent fuel and nuclear waste) in the region of £40 billion. With respect to the costs of future waste disposal, provisions are currently being made in the accounts of the waste producers. There

WASTE MANAGEMENT: UK	
	is no separate fund to provide for this. With respect to decommissioning costs, again provision is being made in the accounts of the owners of the liabilities, except in the case of the privatised British Energy, where a decommissioning fund has been set up. * 1 £ = 2.3 CAD (2003)
Public Involvement *Approaches at national, state, and community levels*	Following the failure of the NIREX LILW siting program, the Government in the UK built up a very extensive program aimed at public consultation on future strategies for managing all types of radioactive wastes. This involved widespread distribution of documents soliciting feedback, citizens panels, public hearings focus groups, etc. The lengthy process foreseen for this consultation will result in policy decisions in the year 2007.
International Cooperation *Main international partners; major cooperative projects*	UK plays an active role in projects of the EU, the NEA and IAEA. The UK does not have any URL but participate in two URL's: Whiteshell in Canada and Äspö in Sweden, both granite. UK plays an active role within the Cassiopee consortium, the Club of Agencies and is a member of the International Association for Environmentally Safe Disposal of Radioactive Materials – EDRAM, see chapter 3.1.4.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.british-energy.com (Owner of HLW/SNF) www.bnfl.com (Owner of HLW/SNF) www.ukaea.org.uk (Owner of HLW/SNF) www.nirex.co.uk (Company responsible for management and disposal of LILW) www.defra.gov.uk Department for Environment, Food & Rural Affairs) www.hse.gov.uk (Health and Safety Executive)
Additional Information	As with many countries, the waste management program in the UK has been subjected to repeated political and public pressures. The effects on the UK programs for all categories of radioactive wastes have been especially pronounced (abandonment of surface LLW sites, failure of Sellafield LILW project, dropping HLW drilling programs).

WASTE MANAGEMENT: USA	
Nuclear Activities *Nuclear power program*	The US has built 119 commercial light water reactors of which 15 are permanently shut down and 104 are still in operation. The 104 reactors supply some 20% of the of the national electricity production. Their total capacity amounts to about 99,000 MWe. The 104 operating reactors are mostly licensed for 40 years. A significant fraction of the owners of the reactors have expressed an intention to apply for 20-year extensions. Recently, the first such operating license extension was granted. The US has 3 nuclear reactors under construction. The US also has all other NFC facilities (U-mining, fuel fabrication, and the capacity for reprocessing), but not yet HLW disposal.
Waste Categories and Quantities *Categorisation of radioactive wastes; quantities of SNF and HLW*	The US operates with the following main waste categories for commercial reactors: • HLW – High Level Waste • LLW – Low Level Waste ○ Various levels, including those classified as ILW by other nations. The Department of Energy has a separate waste classification system. The US commercial reactors contribute between 1,800 and 2,200 tonnes annually to the accumulation of SNF. Projected SNF discharges, taking into account plant life extensions, could bring the total to 105,000 tonnes by the year 2046. The US has 230 m^3 of vitrified HLW from a civilian reprocessing facility, West Valley, operated from 1966 to 1972.
Legal and Regulatory Framework *Implementing and regulatory bodies; advisory groups; main legislative instruments*	The US Department of Energy (USDOE), through its Office of Civilian Radioactive Waste Management (OCRWM) is responsible for • The final disposal of SNF and HLW. • Repository site selection, licensing, construction, operation and closure. • Collecting fees to fund the disposal of SNF and HLW, assessing the adequacy of the fee and recommending changes in the fee. The nuclear utilities are responsible for the storage of SNF until it is accepted by USDOE. The regulatory authorities consist of • Nuclear Regulatory Commission (USNRC)

<table>
<tr><th colspan="2">WASTE MANAGEMENT: USA</th></tr>
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<li style="list-style:none">
Establishes technical requirements for repository licensing, consistent with EPA standards.
Responsible for granting the repository construction license, approving receipt and possession of nuclear material and approving closure of the repository.

Environmental Protection Agency (EPA)
Establishes standards on public health and safety.

The oversight body is the Nuclear Waste Technical Review Board (NWTRB)

Provides independent technical and scientific oversight.
Reports its findings to Congress and the Secretary of Energy.

The President

Makes the site designation decision.
Submits the site recommendation to Congress.
Requests Congressional approval of the budget for the program.

Congress

Enacts laws.
Provides direction through appropriate legislation.

The major laws and regulations applicable to the management of HLW and SNF are

The Nuclear Waste Policy Act of 1982 (NWPA)
The Nuclear Waste Policy Amendments Act of 1987 (Amended NWPA)
The Energy Policy Act of 1992
Various sections from the Code of Federal Regulation (CFR)

</td></tr>
<tr><td>SNF/HLW Management Strategies

National policy and strategy; planned infrastructure;</td><td>
Since the recommendation of the US National Academy from 1957, the US long-term strategy for HLW/SNF management has always been geological disposal. Originally two repositories were planned. However, the 1997 Amendment to the NWPA states that OCRWM should focus its investigation on a potential site at Yucca Mountain, Nevada.
The OCRWM is currently working on development of a deep geological repository at Yucca Mountain for disposal of SNF and HLW. The primary characteristics of the proposed repository are:

Capacity for 70,000 tonnes HM or equivalent.
At least 200 m below the surface and at least 100 m above the water table.
Tuff volcanic rock.
Engineered barriers will consist of a cylindrical waste package composed of a corrosion-resistant outer barrier (alloy 22) and a corrosion-allowance inner barrier (stainless steel 316NG). A titanium drip shield is planned and types of emplacement drift backfilling are currently being evaluated.

</td></tr>
</table>

WASTE MANAGEMENT: USA	
	The space allocation for commercial reactors at the Yucca Mountain repository is for 63,000 tonnes of SNF and 640 tonnes of HLW. The US does currently not have an official policy regarding the open or closed nuclear fuel cycle. Although the Government declared a moratorium on domestic reprocessing of commercial SNF in 1977, this was rescinded in 1992. However, commercial reprocessing never resumed because of economic arguments.
Status of Implementation *Current and planned storage and disposal facilities; practices or plans for co-location of wastes; timescales for implementation; underground research laboratories*	All operating nuclear power reactors are storing SNF in on-site spent fuel pools or one of the 27 independent spent fuel storage installations (ISFSI) at reactor sites. Out of the 27 ISFSIs, 26 are of the dry (cask) type and 1 is of the wet (pool) type. There is a growing concern about lack of interim storage space. This has led to a private initiative, PFS, wishing to implement cask storage in Utah. A deep geological repository is planned in Yucca Mountain, Nevada. The schedule for completion of key activities, subject to a final decision that the Yucca Mountain site is suitable, is as follows: • 2002: The US Congress and the President approved the Yucca Mountain site for repository development. • 2004: USDOE submits a license application to the USNRC. • 2007-2008: USNRC issues a construction authorization. • 2010: Initial waste acceptance and disposal. • 2033: The first 70,000 tonnes would be disposed of. Decision on the need for a 2nd repository will not be taken before 2006. Several types of non-fuel-bearing wastes associated with SNF are expected to be accepted for disposal in the repository. These include control rod assemblies and blades, in-core instrumentation and compacted fuel assembly hardware from fuel assembly consolidation. The USDOE is operating a purpose-built URL, Busted Butte, at Yucca Mountain. A second URL is at the (operating) WIPP repository for transuranic waste (TRU). Two US URLs have been closed down: • Climax (granite) was in operation from 1978 to 1983. • G-tunnel (tuff) was in operation from 1979 to 1990.
Approaches to Siting	Between 1954 and 1975, the US conducted studies of potential

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Siting process; current status

repository sites in salt. Between 1976 and 1982, the search was expanded to include shale, basalt, and crystalline rocks.

A formal siting process was developed under the USDOE siting guidelines (10 CFR Part 960), as required by the NWPA. This process was applied to develop nine sites for consideration for the first repository. In 1986, the President approved three of these sites for characterization (in salt, basalt and tuff). After that, the Amended NWPA passed by Congress selected Yucca Mountain as the only site to be characterized. A site characterization plan was developed for the Yucca Mountain site in 1988.

On July 23, 2002, after the Congressional vote of approval, the President signed the Yucca Mountain Resolution determining that a licensing application should be prepared.

Finance and Economics

Cost estimates for disposal; financing method

The summary of the total system life cycle cost estimation for SNF and HLW is shown in the following table:

Cost element	**Cost million USD* (2000)**
Monitored Geologic Repository costs:	42,070
Development & evaluation (1983-License application)	6,580
Surface facilities	7,700
Subsurface facilities	8,980
Waste package & drip shield fabrication	13,290
Performance confirmation	2,270
Regulatory, infrastructure & management service	3,250
Waste acceptance, storage & transportation	5,960
Nevada transportation	840
Program integration	4,070
Institutional costs	4,580
Total	**57,520**

Expenditures for the for final disposal of HLW and SNF program are financed by the Nuclear Waste Fund (NWF) for commercial SNF, and by the Federal Government's general appropriation for Government managed wastes.

Evaluation of fee adequacy is based on the principle of full-cost recovery, as required by the Nuclear Waste Policy Act (NWPA). Nuclear utilities are required to pay the fee to NWF through the US Treasury. For SNF generated prior to enactment of the NWPA, nuclear utilities were required to pay a one-time fee.

This fund rests with the Treasury, but is not a "proper fund" in the sense that the money rests in a specific bank account. Rather, it is like a social security fund, where incoming funds are used to finance general Government expenditure, and funds drawn down are financed directly from the Government purse.

For commercial SNF, the charge for disposal cost is 1 mill (0.1 cent)

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	per kW•h of electricity generated and sold. The fee has remained constant since establishment of the system. The NWPA allows Congress to change the fee if it becomes inadequate to cover projected program costs. * 1 USD = 1.32 CAD (2003)
Public Involvement *Approaches at national, state, and community levels*	In general, during the progress of promulgating new requirements, draft documents are provided to local governments for review and comments. In particular, the State of Nevada and units of local government in the vicinity of the candidate site at Yucca Mountain were entitled to exercise oversight of site characterization activities and provide comments and recommendations resulting from their oversight to the Secretary of Energy. The NWPA includes specific provisions to ensure participation of members of the public and affected Native American tribes in the decision-making process. The public, including affected Native American tribes, are involved in all phases of the program such as review and comment on siting guidelines, environmental assessment, environmental impact statement, and site recommendation; participation at planning and review meetings; and county and university participation in site characterization. OCRWM promotes two-way communications with technical audiences and the general public through a multi-faceted outreach program, including activities such as: • Organized tours to Yucca Mountain and making briefings. • Exhibition and presentation of Yucca Mountain activities at various conferences and events. • Communicating via the Internet and toll-free telephone line. • Provision of documents. Educational activities are provided to students, teachers and parents by workshops, environmental studies (including field trips), etc. During site characterization, USDOE reports semi-annually to the USNRC and the Governor and legislature of the State of Nevada on the progress of site characterization activities and information collected. The USDOE has a communications staff that is responsible for developing, conducting and evaluating public communication activities. The cost of these activities amounts to approximately 1% of the cost of the overall site characterization effort.

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International Cooperation *Main international partners; major cooperative projects*	USA plays an active role in projects of the NEA and IAEA. Bilateral agreements between OCRWM and many countries and also between USNRC and various national regulators. USA is a member of the International Association for Environmentally Safe Disposal of Radioactive Materials – EDRAM.
Useful Internet Sites *Sites of implementers, regulators; government departments*	www.energy.gov (Department of Energy) www.nrc.gov (Nuclear Regulatory Commission) www.epa.gov (Environmental Protection Agency) www.nwtrb.gov (Nuclear Waste Technical Review Board) www.ncrp.com (National Council on Radiation Protection)
Additional Information	The USA has the largest nuclear program in the world and the most aggressive HLW/SNF disposal plans. If the licensing process for Yucca Mountain is not blocked by legal disputes, the first repository emplacing SNF will be there. The technocratic but transparent siting process leading by multi-attribute analyses to three sites was short-circuited by the decision of Congress to focus on Yucca Mountain. The opposition of the State of Nevada to this decision has been continuous. Nevada cannot formally block the repository, its veto having been overridden by Congress; however, the non-cooperation of the State continues to make difficulties and delays for USDOE.