Nuclear Development
2008

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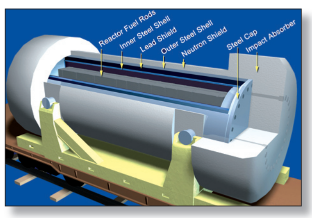
Timing of High-level Waste Disposal



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Nuclear Development

Timing of High-level Waste Disposal

NEA No. 6244

NUCLEAR ENERGY AGENCY
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In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

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FOREWORD

Nuclear energy, which is an important component of energy mixes in many OECD countries and is nearly carbon-free, can help address the challenges raised by ensuring a secure supply of energy and alleviating the risks of global climate change. However, civil society concerns about certain aspects of nuclear energy, including high-level waste disposal, remain high. It is therefore widely recognised that addressing spent fuel and high-level waste disposal is essential in order to gain public acceptance. This is an important issue for all countries with an existing nuclear programme, whether it is intended that nuclear power should be phased out or expanded, as the waste already exists and must be managed. It is equally important for countries with no nuclear power plants currently in operation but planning to implement a nuclear power programme.

High-level radioactive waste (HLW) accumulated since the early development of nuclear power can be safely stored in interim storage facilities, although experts generally believe that long-term management of such waste should be based on deep geological disposal. Considerations of security and inter-generational equity suggest that geological disposal should be implemented as soon as possible. However, many opponents to nuclear energy argue that there has been insufficient demonstration of the long-term safety of deep geological disposal and that there should be a moratorium on building new nuclear power plants until the issue of long-term management of HLW is resolved. These arguments have a powerful influence on public opinion towards both the construction of a waste repository and the building of new nuclear power plants.

In this context, the intent of this study, carried out under the auspices of the NEA Nuclear Development Committee, is to identify the factors influencing the timing of implementation of a HLW disposal strategy and, based on current experience, to illustrate how these factors are affecting national strategies. It should be noted, however, that the study does not prejudge the policies of individual member countries towards nuclear energy or radioactive waste management, and should not be taken to imply the full agreement of all countries. The impacts of factors such as social acceptability, technical soundness, environmental responsibility and economic feasibility on the timing of HLW disposal are investigated. The study also presents examples of responses to public concerns and requirements in national policies and strategies for radioactive waste management taking into account social, political, economic and environmental aspects.

A key challenge of HLW disposal strategies is to ensure timely implementation of final disposal while achieving the necessary public acceptance through participation of stakeholders in an open and transparent decision-making process. The study concludes that the prospect of a nuclear renaissance enhances the need for strengthening public confidence in the solutions that will be proposed for HLW disposal and the involvement of civil society in the decision-making process. It highlights the need for better public information on waste management and disposal issues, and stresses that implementation of national programmes will continue to be delayed as long as the public remains unconvinced that the solutions being proposed are satisfactory.

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EXECUTIVE SUMMARY

The world is facing energy difficulties for the future, in terms of security of supply and climate change issues. Nuclear power is virtually carbon free. Whilst it cannot provide a complete answer to these challenges, it is certainly capable of providing a significant component of the answer.

However, nuclear power remains controversial. In order for it to gain public acceptance, it is widely recognised that a number of key issues need to be addressed:

- demonstrating safety;
- demonstrating economic attractiveness;
- countering proliferation risks;
- further progressing in solving the long term management of radioactive waste.

The present study relates to a particular aspect of radioactive waste management: the timing of the disposal of high-level waste (including spent nuclear fuel). This is an important issue for all countries with an existing nuclear power programme, whether or not it is intended that nuclear power should be phased out or expanded – the waste already exists and must be managed in any event. It is equally important for countries planning a new nuclear power programme where none has previously existed. Some of the discussion and conclusions will be familiar to those already involved in implementing HLW strategies. The intended audience is those who are not already versed in these issues.

Since nuclear power was first developed over fifty years ago, spent fuel and the high-level waste arising from the reprocessing of spent fuel have been stored as an interim measure. It is widely believed (though not by many opponents of the nuclear industry) that long term management of such wastes should be based on deep geological disposal. Considerations of security and inter-generational equity suggest that geological disposal should be implemented as soon as possible. However, many opponents argue that there has been insufficient demonstration of the long-term safety of deep geological disposal. The same opponents also argue that there should be a moratorium on building new nuclear power plants (NPPs) until the issue of long-term management of HLW is resolved. These arguments have a powerful influence on public opinion towards both the construction of a waste repository and the building of new NPPs.

The intent of this document is not to arrive at judgements, but to identify and discuss some of the factors influencing the timing of the implementation of a radioactive waste disposal strategy and to demonstrate to decision makers in member countries how these factors are affecting country strategies, based on current experience.

There is a wide range of factors which affect the timing of HLW disposal. The study examines how social acceptability, technical soundness, environmental responsibility and economic feasibility impact on the timing of HLW disposal and can be balanced in a national radioactive waste management strategy taking the social, political and economic environment into account. It shows examples of strategic responses to public concerns and requirements regarding a national radioactive waste management approach.

As a conclusion the study emphasises that regardless of whether national policies are to phase out or continue with nuclear power, repositories for the disposal of HLW will be needed to deal with existing wastes. If demand for nuclear power expands globally, even further efforts are needed to implement HLW disposal. A key challenge for the nuclear industry is timely implementation of final disposal, and at the same time achieving the necessary public acceptance through participation in an open and transparent decision-making process. The study analyses the results of the Eurobarometer 2005 and its 2006 update data and concludes that public concern with respect to radioactive waste disposal is a key factor in reducing public support for nuclear energy in general. One of the major factors dictating the long timescales for achieving final repositories is a failure to further improve public trust and confidence, and further improve public involvement in the selection of the proposed solutions. If governments wish nuclear energy to be part of their energy mix, their publics need to be much better informed with respect to the issues surrounding radioactive waste management and disposal. As long as a significant fraction of the public continues to hold misconceptions on radioactive waste management, public opinion will continue to cause delays in HLW disposal programmes.

The detailed analysis in Chapter 5 has largely confirmed the initial views of the technical experts as set out in Chapter 2. It is clear that the messages from the work of the Radioactive Waste Management Committee (RWMC) and other analysts, highlighting the importance of stakeholder issues at all levels, have been understood and absorbed by the community of waste management experts. No longer are the technical issues regarded as the dominating factors. The experts' initial views and the public's view, as extracted from the Eurobarometer data, still differ in three significant areas. A majority of the public, in both countries with and without nuclear power, believe that there is currently no safe solution for radioactive waste disposal. This indicates that confidence in scientists and experts still has to be built and that further efforts in communication are required. It may also indicate that the public has high expectations from innovative techniques yet to be invented or developed. Similarly the public places considerably more emphasis on security and radioactive waste transport issues than the Expert Group (EG) believed should be the case.

The development of the technical and scientific case for a repository is obviously the other key area that demands a significant timescale. The safety case for a HLW repository is of the utmost importance and the needed research efforts are extensive and time consuming. Further, in an open society the final selection of a disposal concept and of a site will be challenged by stakeholders from every possible angle. Strong arguments must be available to show that the optimal overall choice has been made from a safety point of view as well as from the technical, economic and social viewpoints. Extensive scientific and technical background material will give a solid basis for the arguments in this discussion. The trend is that the public dialogue and the decision-making process are becoming increasingly important and the time needed should be considered and not underestimated.

Summary of overarching conclusions:

- It seems to be a generally agreed principle amongst the industry, the public and politicians that each generation that benefits from nuclear power should honour its responsibilities and should deal with its radioactive waste in a manner that protects human health and the environment, now and in the future, without imposing undue burdens on future generations. This ethical principle of "intergenerational equity" is a driver to avoid undue postponement of HLW disposal.

- There is a broad agreement among experts that deep geological disposal is technically feasible and constitutes a safe option for the relatively small volumes of HLW compared to other toxic waste types.
- Interim storage of HLW could continue for many more decades, provided that proper controls and supervision continue. However, this can only be an interim solution; at some point a final disposal solution must be implemented.
- The general political climate regarding nuclear issues, and political stability and continuity of decisions already made on principles and time schedules, will influence the views of the general public and its confidence in the decision-making process and thereby the timing of the implementation of HLW disposal.
- There is clear evidence that significant fractions of the public still have serious misconceptions with respect to the issues surrounding nuclear waste. The nuclear industry, together with governments in those countries who would like a component of nuclear power in their energy mix, has a responsibility for and a significant challenge in presenting its case to the public. A number of OECD governments (e.g. France, Germany, Japan, Republic of Korea, United Kingdom), are undertaking public consultation exercises as part a wider process of establishing a consensus.
- Opponents to nuclear energy often claim that further expansion of nuclear power would drastically increase the radioactive waste problem. Since the generated volumes are small and a timely implementation of HLW repositories will still be needed for already produced quantities of HLW, irrespective of any future expansion of nuclear power, this argumentation is spurious.
- If terrorist and proliferation risks are high on the political agenda these may act as new drivers in the implementation of HLW disposal systems.

Summary of issues important for timing of HLW disposal:

- Most countries already have well developed waste management programmes with time schedules for disposal implementation. However, experience has shown that, in practice, the time schedules originally envisaged prove to be ambitious. This is driven by the twin factors of the scientific detail needed to prove the choice and the technical acceptability of a chosen site, and the time taken to gain public and political acceptability for the outcome choices.
- The availability of suitable host geological formations and the number of potential sites are generally good in most countries and are not a limiting factor for timing from a technical view point. Technically matured disposal systems, comprising sites, civil works and waste packages, each contributing to the functions required to ensure short and long term safety, are developed in several countries and are generally not a limiting timing factor. However, the societal and political acceptance of these systems is currently the limiting factor for implementation in most countries.
- The clear commitment and support of successive governments towards a national radioactive waste management programme will help its timely implementation and are important factors in reaching a publicly acceptable disposal solution.
- Clear legislation and well-defined roles of the actors in the decision-making process at the local, regional and national levels are key factors in a successful and timely HLW disposal programme.
- The structure and transparency of the decision-making process and the level of and possibility for public participation are key issues for achieving public acceptance. Much progress has been made in developing stakeholder dialogue and transparent public

consultation. This work is time consuming and has a large impact on the timing of HLW disposal.

- The level and availability of funds is an important factor which can influence the timing of HLW disposal. All countries considered have arrangements for collecting the appropriate funding from the waste producers to ensure this does not become a limitation.
- The availability of skilled staff should be planned over the implementation period to avoid unnecessary interruptions in what has become a very lengthy process in many countries.
- International cooperation can shorten the time needed in the implementation process by avoiding duplication of research and sharing lessons on stakeholder engagement.
- R&D on new technologies has the expected potential of significantly reducing the quantities of long-lived radioactive waste resulting in reduced volumes for disposal in a repository. It also holds appeal to people who are unconvinced by current proposals for deep geological disposal and are especially concerned about the long lived isotopes. This may be a driver for delay in progressing with a repository. R&D into partitioning and transmutation is not simply a response to public concern. It is part of a responsible and ethical approach towards good resource management, i.e. sorting, recovery, recycling and therefore resource saving. However these technologies need significant development and time before they are deployable at a commercial scale. Geological disposal of currently vitrified wastes and of fission product wastes will still be needed, even in the event of successful commercial deployment of partitioning and transmutation technologies.

The report does not prejudge the policies of individual member countries towards radioactive waste disposal.

Acknowledgements

The Secretariat would like to acknowledge the valuable contributions to this project made by the members of the Expert Group, Jean-Marie Deconinck (Belgium), Frantisek Woller, Antonin Vokal (Czech Republic), Timo Seppala (Finland), Richard Poisson (France), Ingo Müller-Lyda (Germany), Shigenobu Hirusawa (Japan), Jongwon Choi, Heui-Joo Choi (Republic of Korea), Wolfgang Hilden, Simon Murphy (European Commission), Bernard Neerdael, Lumir Nachmillner (IAEA), with special thanks to Guy Demazy (Belgium) for his chairmanship of the group.

Chapter 1

INTRODUCTION

The total volume of high-level radioactive waste (HLW) from nuclear reactors is relatively small. There is a broad agreement among experts that deep geological disposal, after a reasonable cooling time in interim storage, is technically feasible and constitutes a safe option [33] at an acceptable cost. A key issue, however, is the time-scale for developing such a final disposal solution.

Determining an optimum timescale may be affected by strategic, technical, economic, political and social factors and, in turn, raises issues in all those regards. Although the approach to waste management and disposal is driven by national policy goals and context, a comprehensive international review of issues at stake could provide decision makers with an authoritative overview relevant in the context of communicating with various stakeholders on national policies.

Many non-governmental organisations (NGOs) are opposed to the final disposal of radioactive waste, arguing that existing wastes should be managed in monitored surface stores until a final disposal option has been thoroughly researched and proven, and that meanwhile further arisings of such wastes should be stopped. By implication, this calls for a moratorium on building new reactors and phasing out existing ones.

However, there is an alternative argument that final disposal of existing HLW should be enabled as soon as possible for both security and inter-generational equity reasons, irrespective of whether or not new arisings are created. In 1995, the International Atomic Energy Agency (IAEA) published a document (updated in 2006) in which fundamental principles of radioactive waste management were formulated [42]. This document constituted the basis for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Principle 7, "Protection of present and future generations", was formulated in this document and has also been reflected in the Joint Convention.

A corollary to this argument is that the question of managing HLW is not directly related to the issues of building new nuclear power stations. In those countries with existing nuclear power programmes such wastes already exist and need to be managed irrespective of future nuclear power developments.

Currently, no country is conducting final disposal of HLW. In many countries, extended interim storage of HLW is applied but as a temporary solution pending the construction of repositories for this type of waste. R&D programmes, including desk studies, computer modelling, laboratory and in situ testing, are ongoing in many OECD countries. The NEA report entitled "*The Roles of Storage in the Management of Long-lived Radioactive Waste*" [1] presents the general practice in the OECD member countries and discusses in detail the difference between storage and disposal from the sustainability point of view. According to this report, *storage is an interim step undertaken while awaiting some further step. In contrast, disposal is the final expected step within a waste management plan, although additional steps might be possible.* In the stated view of the Joint Convention [30], storage can not be an endpoint by definition. Without an endpoint a radioactive waste management strategy is incomplete and, therefore, does not provide for a sustainable solution. If HLW disposal is postponed there may be economic, technical, social and political impacts for the national programme in question.

The main focus of this work is to prepare a "safety case" for deep geological disposal, demonstrating beyond reasonable doubt that no significant hazard from radionuclides returning to the biosphere can occur within a period commensurate with the lifetime of the radioactivity – a timescale measured in tens or hundreds of thousands of years. Finland, Sweden and the United States are furthest along in developing final HLW repositories, although none is expected to be in operation much before 2020. Finland and the United States have each chosen a single site, at which they are conducting the necessary research. A licence application for the repository at Yucca Mountain in the United States is scheduled for submittal to the Nuclear Regulatory Commission (NRC) in June 2008. Sweden is conducting research at two possible sites [20].

1.1 Objective

The study aims at identifying and assessing the impact of technical, economic, social and political factors on timing of HLW disposal programmes through analyses of different country cases.

1.2 Definitions

In the present study, the word *timing* should be construed as the programme of successive actions to be undertaken with a view to stepwise licensing, construction, operating and closing a final disposal facility for high-level waste.

HLW means any form of conditioned high-level waste to be disposed of in a deep geological repository after a period of cooling in interim storage facilities. The definition consequently includes spent nuclear fuel (SNF) for those countries which do not choose to use reprocessing.

Stakeholders are all the parties having an interest in the elaboration, the justification, the licensing, the construction, the operation, the follow-up and the closure of the project, for economic, technical, political, environmental, societal or other reasons.

Interim storage involves storage in a form or at a facility which is not designed as the final form or facility for disposal. For HLW, interim storage for a period of decades is often required to allow the internal generation of heat from radioactive decay to fall naturally to a level compatible with final disposal.

Disposal is the emplacement of waste in a final repository in a solid form which is not expected to require any further conditioning. It may involve a period of monitoring and retrievability before final closure of the repository. The period between emplacement and closure could be many decades.

1.3 Scope of the study

In this context, the NDC decided to include a study on timing of HLW geological disposal in its 2005-2006 Programme of Work.

The scope of the study focuses on:

- technical issues and constraints, connected with R&D on geological disposal and innovative technologies;
- decision-making processes and stakeholders involvement;
- economic, political and other social issues.

In some countries, deep geological disposal is also proposed for long-lived low and intermediate level wastes. Although there are parallels with HLW disposal, this topic has been excluded from the present study because the radioactivity concentrations of the wastes are substantially different. Consequently, there are relevant differences in the timeframes for the natural decay in radioactivity that would allow different approaches and different technical solutions for the long term management. HLW is also widely perceived by politicians and the public as the most challenging waste stream.

1.4 Issues investigated

The study reviewed the following issues, based on input from individual country reports:

- decision-making processes adopted by governments to select strategies;
- identification of assessment criteria;
- sorting of assessment criteria;
- role of national nuclear programme and policy, and of international context.

1.5 Methodology and content

Member countries were invited to nominate experts to work on the project. Country reports were solicited and analysed to collect information from the participating member countries. All countries that contributed to this report have a long-term vision for safe radioactive waste management. Most of them already have well-defined waste management strategies and roadmaps for the implementation of geological disposal.

The main factors influencing timing of HLW disposal implementation were identified by the Expert Group and a first judgement made on their importance in relation to the timing of HLW disposal (Chapter 2). The factors were assessed in terms of their impact on timing, which was classified as *low*, *medium* or *high*. These can be defined simply as:

Low impact: – unlikely to have a significant influence in determining timing.

Medium impact: – may have some influence in determining timing.

High impact: – likely to be a major influence in determining timing.

An important aspect of the assessment has been a consideration of public perception of the nuclear power and radioactive waste management. Clearly, this is a major determinant of government policy towards HLW disposal. Therefore significant use has been made of the results of the 2005

Special Eurobarometer Survey of public opinion towards radioactive waste.[1] The conclusions of this survey relevant to the present study are summarised in Chapter 3.

Chapter 4 summarises the various country reports which are presented in Appendix 4.

A detailed assessment by the Expert Group of the impact of the relevant factors, taking account of the Eurobarometer survey results and the country reports, is shown in Chapter 5.

Chapter 6 presents the short discussion of the outcomes and the decision-making processes.

Chapter 7 sets out the conclusions of the study.

It should be noted that whilst the report identifies and assesses individual factors impacting the timing of HLW disposal, it does not attempt to analyse how these factors might interact. The interaction of several factors might be significant at a national level and lead to a more complex picture, but it would be impossible to carry out a generic analysis at an international level. For example, for a given country both the stability of the repository programme and stakeholder dialogue might be rated high initially. A situation could emerge whereby a change in the legal framework for radiation protection resulted in increased stakeholder trust but at a cost to programme stability.

1. The European Commission performs public surveys on a regular basis. The *Special Eurobarometer 227 – Report on "Radioactive waste"* was published in 2005 [4] and an update in 2006 [32]. This report presents the results of public opinion surveys on the risk perception of radioactive waste and nuclear energy, radioactive waste management and especially on underground disposal. The survey was carried out by interviewing 24 708 citizens in the 25 Member States of the EU.

Chapter 2

IDENTIFICATION OF FACTORS IMPACTING THE TIMING OF HLW DISPOSAL

The Expert Group identified 22 factors which might impact decision making on the timing of the disposal of HLW. These factors are arranged into four main groups (technical, social and political, economic, stakeholder involvement) and are introduced below.

The expectations of the Expert Group with respect to the impacts on timing are indicated in this chapter for each factor under discussion and summarised in Table 2.1. Detailed discussions on the impacts of these factors and the comparison based on the country experiences and the public view, as expressed in the *Special Eurobarometer 227 – Report 2005* [4], are presented in Chapters 3-5.

2.1 Technical factors

The technical conditions required for safe disposal of HLW need to be defined and demonstration that they would be met achieved before any disposal facility can enter into operation.

2.1.1 Quantity of prospective HLW arisings

Countries with large nuclear power programmes are more likely to seek early solutions to final disposal of wastes than countries with small programmes. The economies of scale are such that the unit cost for disposal of small quantities is relatively high, whilst interim storage is more manageable.

Expectation: high impact on timing

2.1.2 Heat production and interim storage

The heat production from HLW falls significantly over a period of several decades as a consequence of radioactive decay. Early disposal to a final repository implies that cooling capability would be required which would not be required (at least not to the same extent) if disposal were deferred by a period of interim storage.

Expectation: high impact on timing

2.1.3 Suitable host rocks

Most countries with nuclear programmes are currently investigating the potential of suitable host formations for deep geological disposal. Where several suitable host formations are equally available, further characterisation and the associated social dialogue are time consuming but may be regarded as necessary in the selection of the most acceptable host rock.

Expectation: high impact on timing

2.1.4 Number of suitable candidate sites

When selecting a site, many different aspects have to be taken into account, including the suitability of its geological characteristics. If multiple possible sites were to be investigated in detail, the time for characterisation and public consultation might increase substantially. However, this could be avoided by narrowing the number of potential sites in a preliminary screening process.

Expectation: medium impact on timing

2.1.5 Transportation of HLW

The number, distance and routes of shipments of HLW will be strongly related to the strategy chosen for the location of the interim storage (local or centralised) and of the final repository. Although experience has shown that transport of HLW is a very sensitive issue for the public and could cause delays in time schedules for HLW disposal operations, the view of the Experts was that it should not have a significant impact on the timing of the development of disposal facilities.

Expectation: low impact on timing

2.1.6 Regulatory standards

Regulatory standards for radiation exposure limits are essential for the whole nuclear cycle, including radioactive waste management, to ensure that health and environmental impacts of waste management facilities and of transport of radioactive wastes remain below socially acceptable limits, even in accident cases. Changes in dose limitations for the long-term may require the safety case for a HLW disposal strategy to be reviewed which might cause changes in the disposal strategy or the design of facilities and consequently impact the timing of final disposal.

Expectation: medium impact on timing

2.1.7 R&D

In countries where a suitable site has already been chosen, the research on host rock media may be narrowed. In other countries the research has to be more broadly based to accommodate alternative host media. This will influence the time for implementing the HLW facility. The principles and final design for the HLW facilities have also to be defined. The progress of this work also impacts the overall time schedule for the HLW disposal system. Some particular technical and conceptual questions might need evaluation for rather long time periods.

Expectation: medium impact on timing

2.1.8 Applied R&D

Development of technical criteria is often done in an iterative way involving both the implementer and the authorities. To verify that technical criteria are met, an extensive characterisation programme has to be performed to collect data for the safety assessment. Additional R&D is required to provide responses to precise technical questions and challenges raised by regulatory agencies.

Expectation: medium impact on timing

2.1.9 R&D on new and/or innovative technologies

Technology improvements may affect the timing of HLW disposal in either direction. There are, for example internationally co-ordinated research activities on radioactive waste minimisation via partitioning and transmutation (P&T). A decision to wait until new technologies are available would delay HLW disposal.

Expectation: medium impact on timing

2.1.10 International collaboration and experience

Nuclear activities in any country may have an impact on programmes in other countries. There is already a well-established international cooperation framework in the radioactive waste management sphere covering research and technology development, regulations and legal aspects, and also exchange of information and technology transfer. An increasing degree of international cooperation is expected in the future. This factor will affect timing of HLW disposal, depending on the technical information and knowledge gained through collaboration.

Expectation: medium impact on timing

2.1.11 Availability of national expertise

The availability of experienced staff for the period considered in the radioactive waste management strategy is essential for the design, construction and operation of the radioactive waste management facilities as well as for regulatory activities and research. HLW disposal programmes could be delayed significantly if the knowledge transfer chain were broken between the generations involved. This problem can of course be avoided by proper management.

Expectation: medium impact on timing

2.2 Social and political factors

During the past 10-15 years it has become increasingly apparent that social and political factors are at least as important as technical and economic factors in determining strategies for radioactive waste management [9].

2.2.1 Importance of the nuclear programme

In countries which already have nuclear power programmes, HLW already exists and a disposal strategy is required whether or not nuclear power expands. However, some countries, particularly those which do not yet have a nuclear power programme, would not contemplate such a programme without a complementary HLW disposal strategy.

Expectation: medium impact on timing

2.2.2 Legal framework

The legal framework inside a country can impact upon strategies with respect to radioactive waste. The radioactive waste disposal strategy might be regulated within the framework for utilisation of nuclear energy, or separately. Early decisions on strategies, including milestones, may be set down in law and might be drivers in the HLW management programme.

Expectation: high impact on timing

2.2.3 Continuity and stability of the decision-making process

The continuity of policies of the government and legislative bodies to the national waste disposal strategy plays a crucial role in the decision-making process. Continuity and stability over time regarding policies are important.

Expectation: high impact on timing

2.2.4 Waste ownership and responsibilities

Legal ownership of the high-level radioactive wastes might change during the process of implementation of a country's national waste disposal strategy. Key players are the waste producers, the government and those specialised national organisations responsible for the long-term safe management of radioactive wastes. The direct impact of ownership has probably a low impact on timing. However, the consequences of an inadvertent break in continuity in technical capability or availability of funding through transfer of ownership might have a high impact on timing (see *2.1.11 Availability of national expertise* above).

Expectation: low impact on timing

2.2.5 International constraints

The regulatory framework of a country with a nuclear programme has to implement international obligations under a Safeguards Agreement with the IAEA pursuant to the international nuclear non-proliferation regime, and the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management. This factor may have an influence on the timing of HLW disposal in either direction.

Expectation: medium impact on timing

2.2.6 Security

Disposing of HLW in deep repositories would increase security against terrorism or nuclear proliferation compared to surface or near-surface storage. Security decisions could therefore influence timing of HLW disposal.

Expectation: from the technical point of view, minor impact on timing

2.3 Economic factors

There is a widely-held view that the generation benefiting from nuclear energy should bear the responsibility for the radioactive waste produced during the operation of nuclear installations, and thereby also the costs. This begs the question: do future generations benefit from today's use of nuclear energy because of enhancement and improvement in the societal framework? Nevertheless, it is essential that adequate funds are available for disposal when needed. Some factors that are important for the accumulation of funds are:

- economic development of the country;
- legal requirements on the build-up of funds, their investment and guarantees of their availability (ring-fencing);
- the chosen strategy for HLW disposal, including time schedule;
- proper cost evaluation of HLW management, including disposal;
- the national nuclear power programme (including design lifetime, possible extension, early phase-out of existing NPPs, etc.);
- discount rate.

Economic evaluation might help the stakeholders to compare the various sets of risks and benefits, which might lead to a better understanding of the chosen radioactive waste management strategy and the timetable for implementation.

However, reducing uncertainties in economic assessments for time periods lasting for some hundreds of years is challenging. Also, economic evaluation might not capture the real significance of, for example, socio-political, technical and environmental factors.

Expectation: high impact on timing

2.4 Stakeholder involvement

In the light of public concern about the perceived risks of radioactive waste management and especially for waste disposal, it is necessary to include all stakeholders in democratic decision-making processes. To gain confidence and trust it is important that the stakeholders' concerns are heard and addressed correctly. Factors related to public discussion are presented below. These are now seen as preconditions to successful realisation of the radioactive waste disposal programme. Current experiences show that delays in some national HLW disposal programmes have occurred due to the lack of an open, transparent and stepwise approach.

It is important that the roles of those in a decision-making process for HLW management are well-defined. Key stakeholders are the government, the regulators, the local communities, the waste producers, the scientific communities and the general public.

2.4.1 National commitment

A strong government commitment to implement a HLW system has been shown to be a forceful driver in a HLW disposal programme.

Expectation: high impact on timing

2.4.2 Involvement of local and regional decision makers

The decision makers in the region and the local communities where HLW facilities might be sited are key actors in the process. Their active involvement is crucial for the timetable.

Expectation: high impact on timing

2.4.3 Public acceptance

Public acceptance and support of a country's radioactive waste disposal strategy and programme are crucial for their successful realisation and will strongly influence the timing of HLW disposal. Public opinion and acceptance levels might differ on the local, regional and national levels.

Expectation: high impact on timing

Table 2.1 Summary of *a priori* expectations of the Expert Group

	Impact expectations		
Factors	Low	Medium	High
Technical			
• Prospective HLW arisings			X
• Heat production and interim storage			X
• Suitable host rocks			X
• Number of suitable candidate sites		X	
• Transportation of HLW	X		
• Regulatory standards		X	
• R&D on the disposal system and its design		X	
• Applied R&D		X	
• R&D on new and/or innovative technologies		X	
• International collaboration and experience		X	
• Availability of national expertise		X	
Social and political factors			
• Importance of the nuclear programme		X	
• Legal framework			X
• Continuity and stability of the decision-making process			X
• Waste ownership and responsibilities	X		
• International constraints		X	
• Security	X		
Economic factors			X
Stakeholder involvement			
• National commitment			X
• Involvement of local and regional decision makers			X
• Public acceptance			X

Chapter 3

THE SPECIAL EUROBAROMETER 227 – REPORT ON "RADIOACTIVE WASTE" 2005

An opinion poll was conducted in 2005 by the European Commission as part of the Eurobarometer series. The report analyses Europeans' perception of issues associated with nuclear power and radioactive waste. In each country, a series of questions was put to a representative sample of the national population aged fifteen and over. In all, 24 708 people were questioned in the 25 EU Member States.

The *Special Eurobarometer 227 – Report on "Radioactive waste"* [4] has been used in this study to explore the level of knowledge and the opinions of the public on the issue of radioactive waste disposal, because it is an especially rich source of data. Consistent questions were asked across 25 countries, allowing direct comparisons to be made. While the data from surveys are available in many countries, the differences in the questions asked make general interpretations much more difficult.

The findings of the Eurobarometer 2005 Report are outlined below. Specific points relevant to the present study are as follows:

- Six out of ten Europeans acknowledge the benefits of nuclear energy supply, reducing dependence on oil and lowering greenhouse gas emissions. This recognition is significantly higher in countries which already have nuclear power plants. However, it still leaves a significant fraction which does not recognise these benefits.
- Only 37% are in favour of the use of nuclear power, compared with 55% who are opposed. However, if the issue of radioactive waste were considered to be resolved, support for nuclear power would rise to 58%.
- Europeans consider themselves not well informed about radioactive waste management. They tend to greatly overestimate the volumes of radioactive waste arisings compared with the volumes of other toxic waste, and to overestimate the risks associated with the storage and transport of even low level radioactive waste.
- Citizens almost unanimously believe that decisions for solving the problem should be taken now rather than left for future generations. They want to be directly involved in decisions about the construction.
- They recognise that it is politically unpopular to make such decisions.
- The statement that deep underground disposal is the most appropriate solution for the long-term management of these materials is accepted by 45% of respondents, whereas 38% disagree.
- Eighty per cent agree with the statement there is no safe way of getting rid of highly radioactive waste.

There is a danger, of course, that these European data do not reflect the position in OECD countries in other continents. However, the outcome from a recent survey in Canada shows a similar pattern, in as much as very limited comparisons can be drawn [36]. (See Appendix 4.7) This, together with the country reports and other examples, suggest that the issues are broadly similar with the publics of all OECD countries.

Six out of ten Europeans acknowledge the benefits of the use of nuclear energy as regards diversification of energy supply, reducing dependence on oil and lowering greenhouse gas emissions (Figure 3.1). Nevertheless, only 37% are in favour of the use of nuclear energy, compared to 55% who are opposed (Figure 3.2). However, if the issue of radioactive waste were considered as resolved, 38% of those who are opposed to the use of nuclear energy would change their opinion. Combining the responses to these questions it appears that a majority of European citizens (58%) would be in favour of the use of nuclear energy, while 31% would remain opposed, if the issue of radioactive waste were considered to have been resolved. The data suggest that the benefit of implementing HLW disposal in Europe would be a 20% increase in public support towards the use of nuclear energy (Figure 3.3).

In general, 75% of Europeans consider themselves not well informed about radioactive waste management. There are a number of misconceptions apparent from the responses which have a significant bearing on how radioactive waste management policy might be formulated and implemented. Eighty per cent of all Europeans think that all radioactive waste is "very dangerous" (in fact, most waste is only slightly radioactive). Seventy per cent believe that the storage and transport of even low level radioactive waste represents a high risk (Figure 3.4). A majority correctly appreciate that radioactive waste is produced by hospitals and general industry, but few have any idea about the volumes involved. Half of respondents think that "radioactive waste is produced in similar quantities to other dangerous waste", whereas in reality it is only a tiny fraction (Figure 3.5).

Eighty per cent of Europeans believe that "there is no safe way of getting rid of HLW" (Figure 3.6). Sixty per cent of Europeans believe that radioactive waste is currently buried deep under ground (in the EU, only Finland has decided to proceed with implementing underground disposal for highly active waste). Fifty per cent believe that radioactive waste is sent to other countries (no country proposes to bury wastes abroad). Thirty-five per cent of citizens think that waste is dumped into the sea, although this practice stopped in 1983.

The perception that deep underground disposal is the most appropriate solution for the long-term management of high-level radioactive waste is accepted by 45% of respondents, whereas 38% disagree (Figure 3.7). EU citizens are fairly unanimous (8 out of 10) in highlighting existing doubts about current management procedures, since "there is no safe way of getting rid of highly radioactive waste".

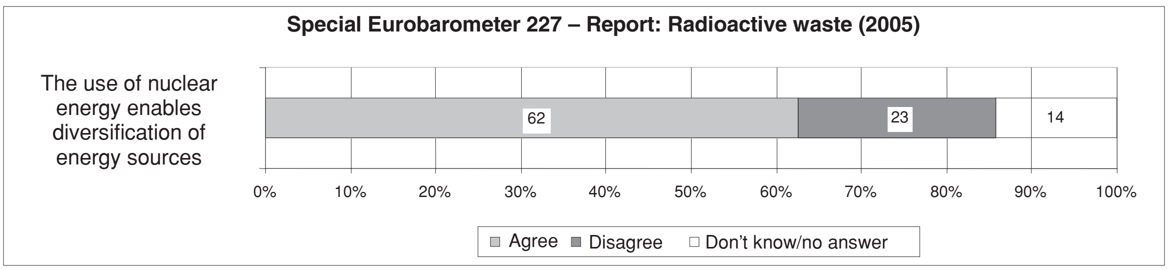
Citizens almost unanimously believe that decisions for solving the problem should be taken now. Further they also consider that they should be directly involved in decisions about the construction of underground disposal sites (Figure 3.8). Eighty per cent agree that taking decisions about the handling of any dangerous wastes is politically unpopular.

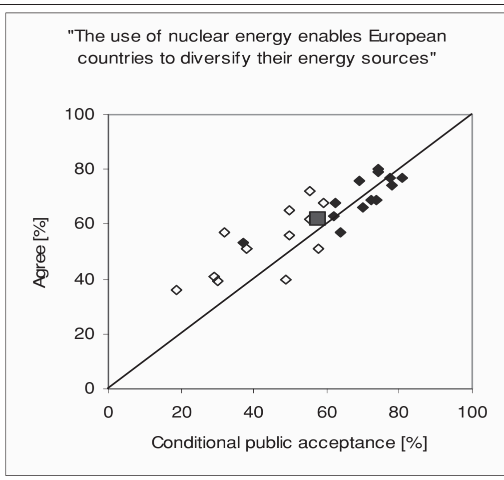
In summary:

- Significant fractions of the population do not recognise the benefits of nuclear power in enabling diversification of energy supplies and reduction of carbon dioxide emissions. If the public does not appreciate the benefits they are less likely to tolerate the disbenefits, such as the need to dispose of radioactive wastes.

- Countries with operating NPPs are, in general, better informed and more supportive of nuclear power than those without.
- For a number of key questions on radioactive waste, however, there is limited or no discernable difference between nations with or without nuclear power.
  - A solution for HLW should be developed now and not left to future generations.
  - The desire for involvement in the decision making process for a repository proposal in their locality (59%).
  - They believe that there is no safe way to dispose of HLW (79%).
  - The low level of agreement that deep underground disposal is an appropriate solution (45%).

Figure 3.1 Public knowledge of role of nuclear energy in diversification of energy sources





Across the European Union, more than six out of ten respondents agree with the statement that the use of nuclear energy enables European countries to diversify their energy sources. This view clearly correlates with high public acceptance.

As can be seen in the graph,[1] there are clear differences in the judgment of people living in countries with or without nuclear programmes.

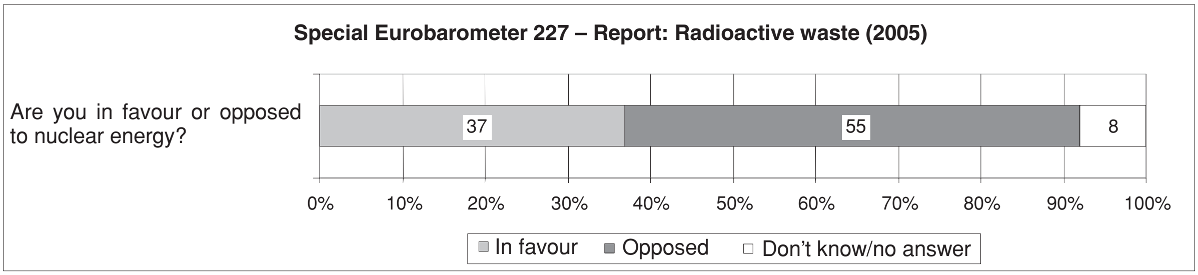
Similar results were obtained on public knowledge of the role of nuclear energy in reducing greenhouse gas emissions.

1. **Key to graphs:** Countries with nuclear programmes are indicated with solid markers, countries without nuclear programmes are indicated with empty markers. The solid square indicates the EU average.
Conditional public acceptance is a sum of positive responses given to the question: "Are you totally in favour, fairly in favour, fairly opposed or totally opposed to energy produced by nuclear power stations?" and the follow up question, if opposed in the previous question "And if the issue of radioactive waste was solved, would you then be ("in favour") to energy produced by nuclear power stations?".

Figure 3.2 Public acceptance of nuclear energy

A majority of citizens in the European Union still oppose nuclear energy. However, another 21% of the public would be in favour of nuclear energy if the radioactive waste issue was solved, which would change the majority situation.

Nevertheless, 57% of opponents of nuclear energy would remain so even if the problems of radioactive waste were resolved.



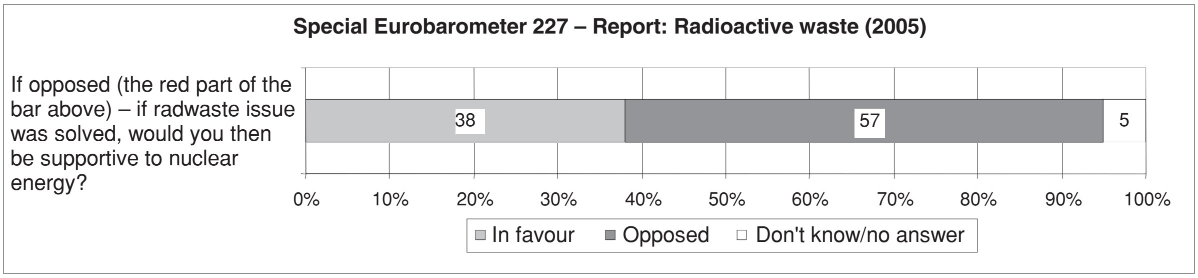


Figure 3.3 Public acceptance benefit in Europe of a HLW disposal solution

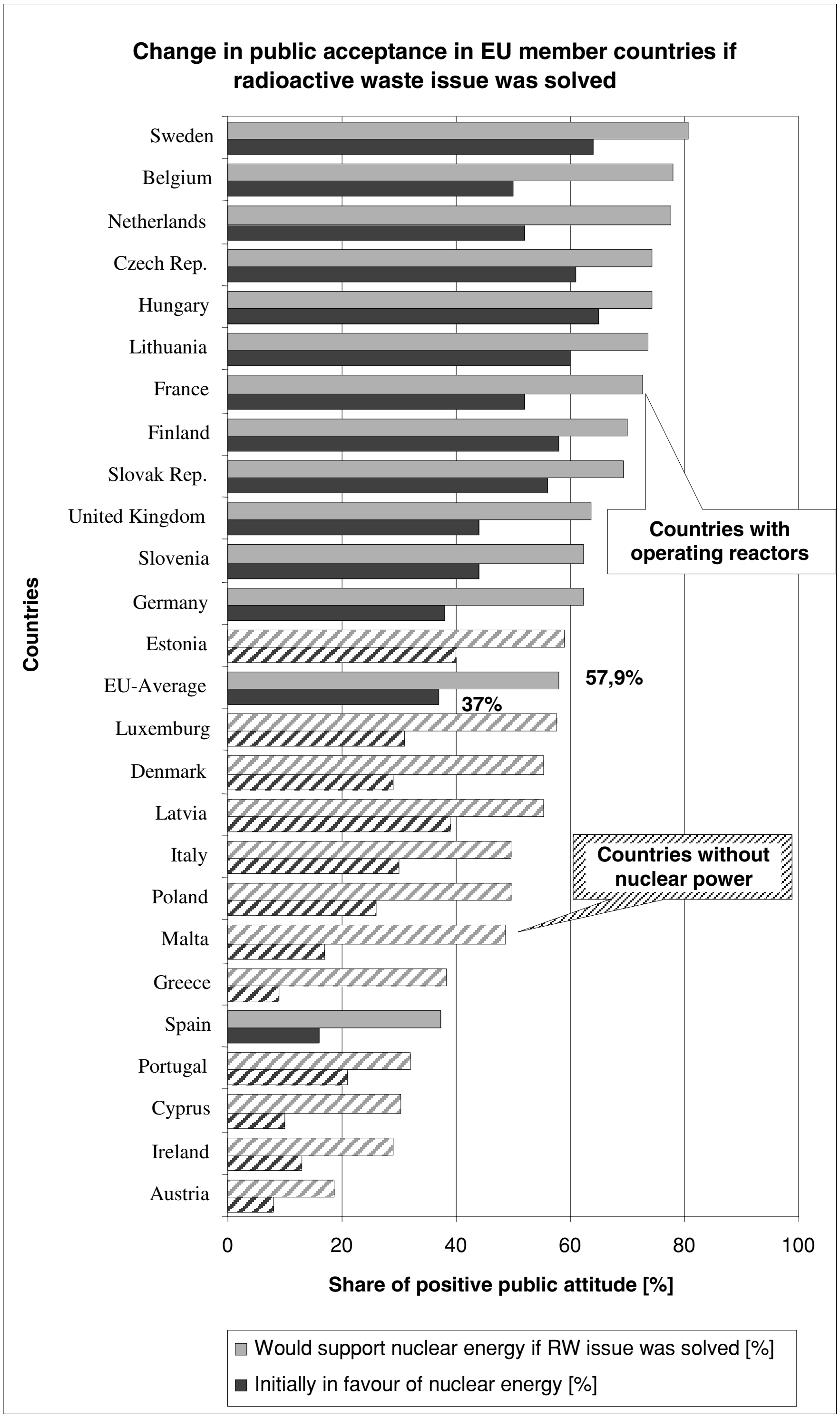
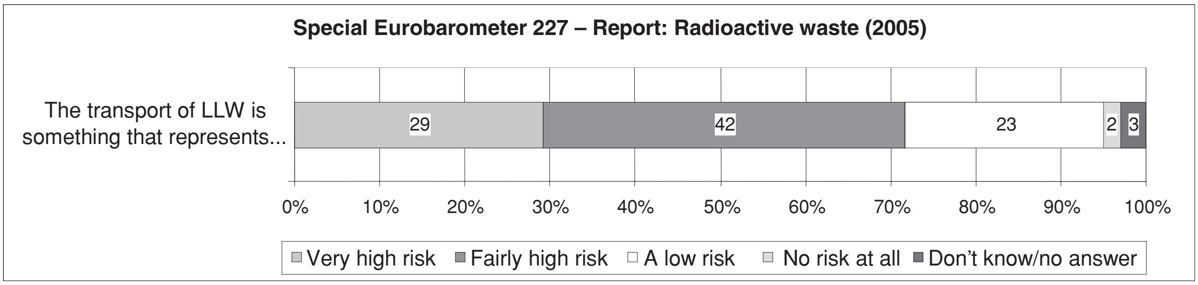
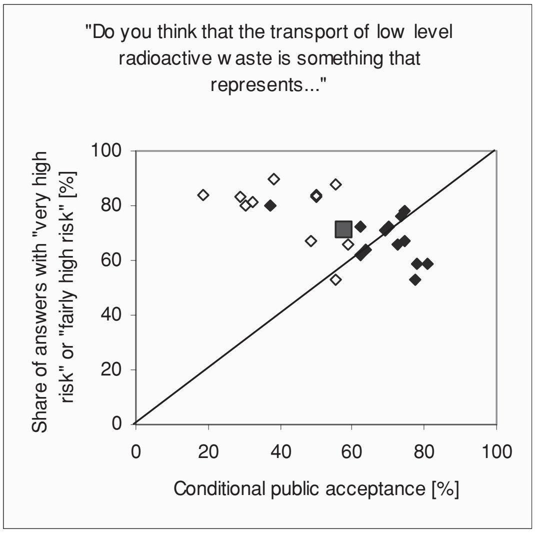


Figure 3.4 Public knowledge on risk of LLW transport



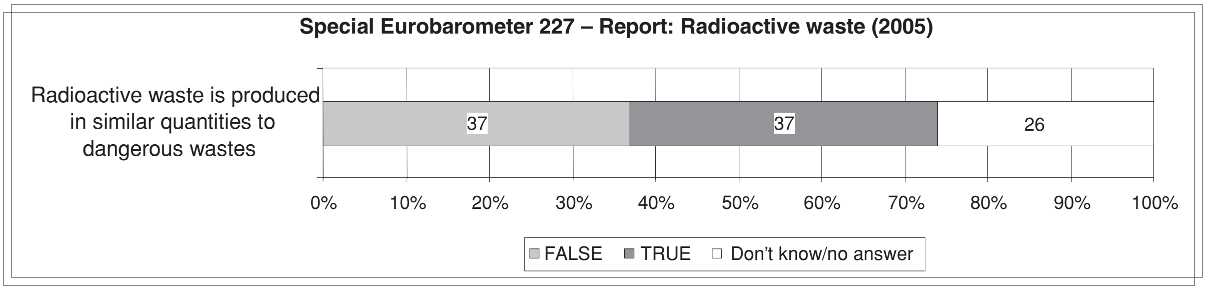


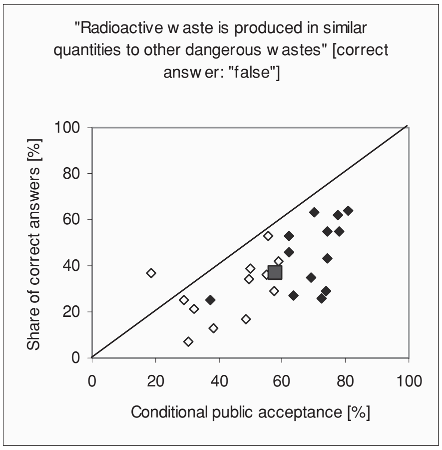
The Eurobarometer did not explore public attitudes to HLW transport. However, it does show that the public is concerned even about low level waste transport. (Similar results were obtained on perception of the risks of LLW storage).

The expert view on the risks of radioactive waste transport is clearly in conflict with the public view. The reason might be a lack of communication regarding the technical details of radioactive waste transports and its real risk.

It can be seen that public is somewhat more informed on the risks of low level radioactive waste transports in countries with nuclear programmes than in countries without. Nevertheless a vast majority of citizens in the European Union believe that transporting even low level radioactive waste carries very high or fairly high risk.

Figure 3.5 Public knowledge on quantities of radioactive and dangerous wastes



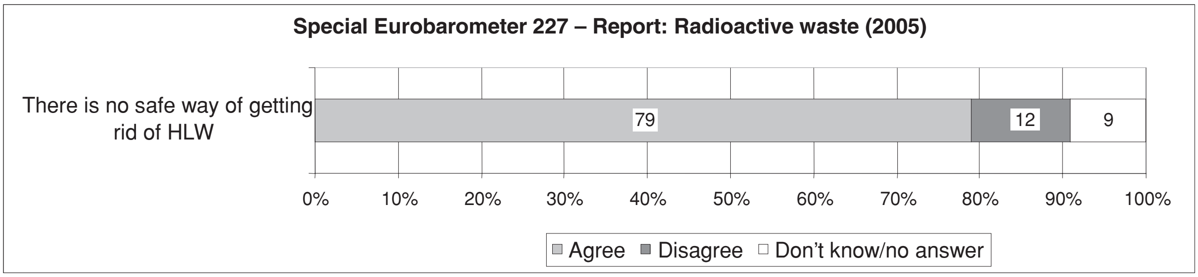


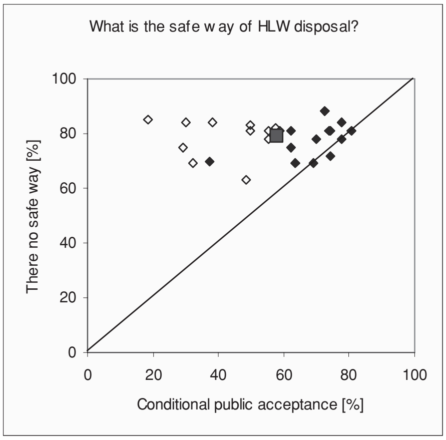
These data clearly show the need to improve public knowledge about radioactive waste volumes, comparing such volumes with non-nuclear waste generation.

Several observations can be made from the Eurobarometer report:

- the majority of people in Europe gave the wrong answer to the question or were unable to give an opinion on this subject in their responses;
- people are more informed on the generated volumes of radioactive waste in countries with nuclear programmes than in countries without;
- the more people are correctly informed on radioactive waste volumes generated, the more they support nuclear energy.

Figure 3.6 Public opinion on safety of HLW disposal

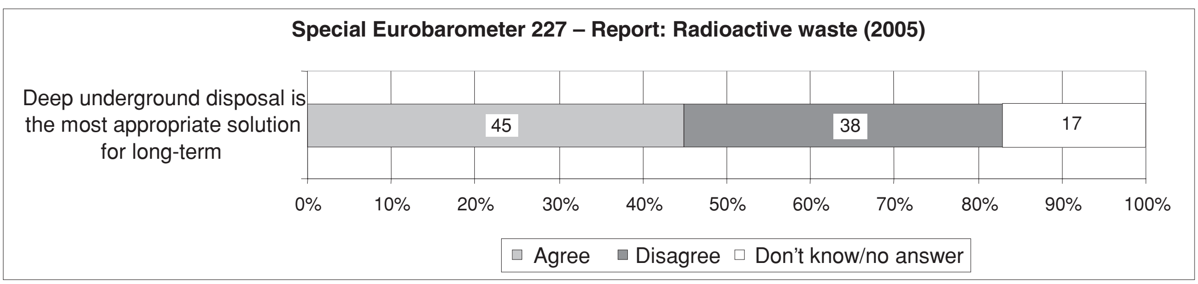


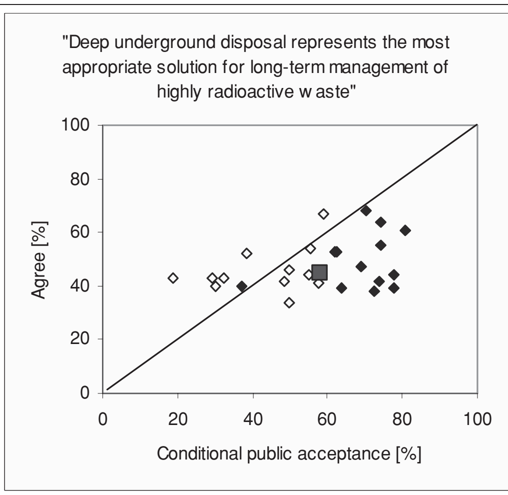


The fact that no decision has been taken on the final disposal of high-level radioactive waste is perceived by nearly eight out of ten respondents as proof that there is no safe way of HLW disposal.

People living in different European countries all seem to have the same view, irrespective of if they come from countries with or without nuclear programmes.

Figure 3.7 Public opinion on long-term HLW management





As can be seen in the diagram above, 45% of respondents see deep geological disposal as the most appropriate solution for the long-term management of HLW, 38% disagree and 17% find it difficult to express an opinion.

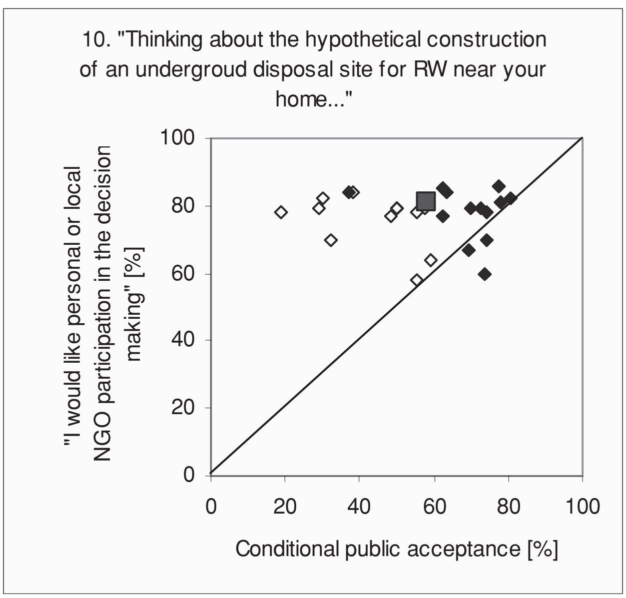
These opinions need to be seen in the light that the majority of European citizens recognise that:

- nuclear energy enables diversification;
- nuclear energy helps to reduce dependence on oil;
- nuclear energy helps to reduce GHG emissions;
- high-level radioactive waste is stored temporarily, waiting for an "unpopular" political decision;

and share the view that:

- a solution for HLW should be developed now and should not be left for future generations. (see Special Eurobarometer Report on Radioactive waste)

Figure 3.8 Public opinion on public participation in decision making



Across the European Union, a majority of citizens would want to be consulted and to play a part in the decision making in the hypothetical case of construction of an underground disposal site for radioactive waste near their home (59%).

Furthermore, 22% of respondents would wish local non-governmental organisations to take part in the consultation and decision-making process in this area.

On this issue there are no differences in the public view in countries with and without nuclear energy programmes. Clearly people will demand to be active stakeholders in the public discussions related to radioactive waste disposal solutions.

This fact amplifies the importance of public participation in the decision-making process and the communication process concerned.

Chapter 4

COUNTRY-SPECIFIC INFORMATION

Individual country reports were provided by members of the Expert Group representing Belgium, Canada, Czech Republic, France, Germany, Japan and Republic of Korea. In addition, five countries (Belgium, Czech Republic, France, Germany and Japan) responded to additional questions specific to the issues considered in this report. The responses to these questions are shown in Appendix 4.

The following paragraphs present a brief summary of the information from these countries. Although they were not represented on the Expert Group, relevant information from public sources relating to HLW policy and plans for Finland, Sweden, the United Kingdom and the United States are included for completeness. This information informs the detailed assessment of factors presented in Chapter 5.

4.1 Summary of country reports

4.1.1 Belgium

In Belgium the long term management of radioactive waste is the responsibility of ONDRAF/NIRAS, a public agency reporting to the Minister of Energy. No formal decision has yet been taken on geological disposal for HLW. However, investigations for deep geological disposal have been in progress for more than 30 years and are focused on argillaceous formations, particularly the Boom Clay layer beneath the Mol/Dessel nuclear zone in NE Belgium. The current R&D programme is aimed at reducing the remaining uncertainties to confirm by 2020 the absence of scientific and technical obstacles for disposal in Boom Clay.

In parallel with the technical programme, a Societal Dialogue is proposed to provide a participative way forward towards site selection and site acceptability.

It is envisaged that implementation of the repository will be carried out in a stepwise process with several phases (licensing, construction, operation, partial closure). No specific regulatory framework for licensing a repository is in place yet but it is considered that a preliminary safety assessment report and an environmental impact assessment will be required to obtain site confirmation.

4.1.2 Canada

The Nuclear Waste Management Organization (NWMO) was established in 2002 to recommend a long-term approach for managing used nuclear fuel produced by Canada's electricity generators. In 2005 it published the outcome of a three year study, engaging specialists and citizens from all walks of life, which recommended a process of Adaptive Phased Management for the long term care of Canada's used nuclear fuel. The Government of Canada has accepted the recommendation and NWMO will implement the approach.

This plan envisages the following steps:

- *Phase 1: Preparing for central used fuel management (approximately 30 years).* Used fuel will continue to be stored at nuclear reactor sites whilst planning activities such as site selection and technology development progress through citizen and regulator engagement towards the development of a central storage facility. Undertake site characterisation, safety analysis and environmental assessment for a shallow underground storage facility, underground characterisation facility and deep geological repository.

- *Phase 2: Central storage and technology demonstration (approximately the next 30 years).* Depending on the outcome of Phase 1, construct a shallow underground storage central facility and begin shipment of fuel. Alternatively, continue to store fuel at reactor sites until a deep repository is available. Conduct research and testing at the underground characterisation facility to demonstrate and confirm the suitability of the site and the deep repository technology. Engage citizens in the process of assessing the site, the technology and the timing for placement of used fuel in the deep repository.

- *Phase 3: Long-term containment, isolation and monitoring (beyond 60 years).* Retrieve used fuel from central shallow underground storage facility or reactor sites, as appropriate, repackage into long-lived containers and place into deep geological repository. Continue monitoring and maintain access to the deep repository for an extended period of time to assess the performance of the repository system and allow retrieval of the fuel if required. A future generation would decide if and when to close and seal the repository.

4.1.3 Czech Republic

Spent fuel is currently stored in dry storage facilities at the Czech Republic's two reactor sites (Dukovany and Temelin). It is envisaged that after a storage time of perhaps 60 years, spent fuel will be transported to a deep geological repository planned to be located in a granite host rock. The Radioactive Waste Repository Authority (RAWRA) was established in 1997 as the state organisation responsible for radioactive waste disposal in the Czech Republic. In 2003, RAWRA completed the screening stage of the siting process for a deep geological repository. This recommended continued geological measurements at six sites. However, due to problems with local acceptance, the government decided in February 2004 to suspend all on-site characterisation work.

Current development work is focused mainly on research of possible processes involved in the migration of radioactive species from a repository and the preparation of safety cases. Further site characterisation work will not continue until 2009, pending engagement with stakeholders from the general public and local representatives.

4.1.4 Finland

In Finland, responsibility of the management of spent fuel lies with the two utility companies which operate the existing four reactors (a fifth is under construction). In accordance with government policy and legislation, deep underground disposal is the chosen route for spent fuel. Implementation of a repository is being carried out by Posiva, a joint company set up by the utilities. In the 1990s four sites were selected for detailed site investigations. In February 1998 Posiva submitted an "Environmental Impact Assessment Programme" to the Ministry of Trade and Industry, and held a series of public hearings in the communities.

Posiva signed a contract with Eurajoki township, at the Olkiluoto potential repository site in 1999, agreeing to the construction of a facility if the government and regulators granted permission. After signing the agreement with Eurajoki, Posiva published the final version of the EIA and submitted an application to the Government for a Decision in Principle. A municipal council vote, as required under Finnish law, was held in January 2000 and was in favour of the facility by 20 to 7. The government approved the Decision in Principle on 21 December 2000, and on 18 May 2001, the Finnish Parliament voted 159/3 in favour of the repository.

Following the investigation phase, it is planned to submit the construction licence application for the disposal facility in 2012 with disposal operations commencing in 2020.

4.1.5 France

The French National Agency for Radioactive Waste Management (Andra) is a public industrial and commercial organisation created by the Law of 30 December 1991. Andra operates independently of waste producers. It comes under the supervision of the French Ministries for Industry, Research and the Environment, and is responsible for the long-term management of radioactive waste produced in France. The Law which established Andra also prescribed a deadline of 15 years for research into the disposal of high level and long-lived intermediate level wastes. The outcome of this research was published in 2005 as two documents known as *Dossier 2005 Argile* (clay) and *Dossier 2005 Granite*.

The studies covered four complementary aspects:

- Acquisition of data concerning the waste packages, material behaviour and clay and granite mediums.
- Repository design: waste conditioning, repository architecture and integration in a geological site, operating modes and reversibility.
- Analysis of the long-term behaviour of the repository and modelling of its thermal, mechanical, chemical and hydraulic evolution.
- Long-term safety analyses.

The work on clay formations was focused on an area of the Meuse region on the border with the Haute-Marne region, initially through drilling extensive boreholes and culminating in the construction in 1999 of an underground laboratory at a depth of 490 metres. In the absence of a French underground laboratory in granite, the research included results of experiments carried out in collaboration with teams in Canada, Finland, Sweden, and Switzerland. The conclusion of the research is that the basic feasibility of geological disposal of HLW in the Collovo-Oxfordian argillaceous formations has been demonstrated.

The work has been subjected to independent peer review by three bodies: a National Review Board established under the Law of 1991, the Nuclear Safety Authority (ASN) and the OECD/NEA. There has also been extensive public consultation.

A new Planning Act was passed by Parliament in June 2006 which states that “the sustainable management of any radioactive material and waste, resulting notably from the operation and dismantling of nuclear facilities using radioactive sources or materials, shall be carried out with a concern to protect human health, safety and the environment.” This Act provides for investigations in three areas:

- **Partitioning and transmutation of long-lived radioactive elements**. Studies and investigations shall be conducted concerning the new generations of nuclear reactors and acceleratordriven reactors dedicated to the transmutation of waste, in order to provide by 2012 an assessment of the industrial prospects of those systems and to commission a pilot facility before 31 December 2020.

- **Reversible waste disposal in a deep geological formation**. Corresponding studies and investigations shall be conducted with a view to selecting a suitable site and to designing a repository in such a way that, on the basis of the conclusions of those studies, the licence application of such a repository be reviewed in 2015 and, subject to that licence, that the repository be commissioned in 2025.

- **Storage**. Corresponding studies and investigations shall be conducted with a view to creating new storage facilities or to modifying existing ones by 2015 at the latest in order to meet requirements, notably in terms of capacity and time.

4.1.6 Germany

Activities related to HLW disposal are the responsibility of three Ministries of the German Government. The Ministry of Economics and Technology (BMWi) is the ministry in charge of R&D under the 5th Energy Research Programme "Innovation and New Technology". The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Ministry of Education and Research (BMBF) are also involved.

BMBF is funding primarily basic research conducted by the national research scientific-technical and biological-medical centres that constitute the Helmholtz-Association. Research on waste disposal is carried out in the national research centres Karlsruhe and Jülich.

BMU, the German regulatory body, is responsible for the disposal projects and the related facility- or site-specific R&D. On behalf of BMU, Federal Office for Radiation Protection (BfS) initiates and coordinates this R&D. BfS is in charge of activities regarding construction and operation of facilities for disposing of radioactive waste using the expertise of third-party organisations.

Since the mid-1960s it has been Government policy in Germany that all radioactive waste should be disposed of in deep geological formations within the national territory. In 1965, the Federal Government purchased a disused salt mine (the Asse Mine) for R&D work related to geological disposal in rock salt. Since the 1970s, extensive R&D has also been carried out in a rock salt dome near Gorleben.

However, there was a significant change in policy following the election of a new coalition government in 1998. As a consequence, in 2000 a limited moratorium was imposed on further work at Gorleben pending the development of a new site selection process. To this end a Committee was established by BMU tasked with developing a site selection procedure for repository sites (AkEnd – Arbeitskreis Auswahlverfahren Endlagerstandorte). The role of AkEnd was to prepare comprehensive procedures for final disposal site selection based on scientific norms. Following the recommendations of AkEnd, BMU intends to investigate further sites in various host rocks for their suitability. Although further decisions have still to be taken on the details of the procedure, the final site will be selected on the basis of a comparison of potential sites, including the Gorleben site. Public participation will be a key element of the selection procedure. The selected site will finally be subjected to a future licensing procedure.

Meanwhile, spent fuel in Germany will continue to be stored at the reactor sites where it arises.

4.1.7 Japan

Responsibility for designing and constructing facilities for the geological disposal of high-level wastes in Japan lies with the Nuclear Waste Management Organisation (NUMO). NUMO is planning to start operation of a repository in the mid-2030s. Site selection will be carried out through a three-step process:

- selection of preliminary areas;
- selection of detailed investigation areas;
- selection of the final disposal facility areas.

The selection process is expected to be completed by around 2025 with design, licensing and construction taking a further ten years. NUMO is inviting municipalities to volunteer as candidate siting areas for literature surveys, which is the first stage in the final disposal project. NUMO, together with the electric utilities is working to foster understanding and awareness by local residents about the advantages and disadvantages for the local community and the importance of construction of the final repository.

4.1.8 Republic of Korea

The Ministry of Commerce, Industry and Energy (MOCIE) has the responsibility of establishing basic policies and project implementation plans for the storage, treatment and disposal of radioactive waste in the Republic of Korea. Government policy stipulates that radioactive waste management should come under the direct control of the government. In 1998, a process was initiated for the selection of a radioactive waste repository site. It was originally envisaged that this would involve co-location of a spent fuel storage facility with a deep repository for low- and intermediate-level wastes (LILW). This was subsequently changed in 2004 such that the LILW disposal facility will be initiated first, with national policy for spent fuel management to be decided at a later date. A new Energy Act passed in February 2006 mandated the formation of a new committee to examine plans for HLW management. Meanwhile, spent fuel will continue to be stored at reactor sites.

4.1.9 Sweden

Responsibility for the management of spent fuel in Sweden lies with the Swedish Nuclear Fuel and Waste Management Company (SKB) which is jointly owned by the four nuclear utilities. SKB is regulated by two government agencies – the Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Institute (SSI). The Swedish National Council for Nuclear Waste (KASAM) is an independent advisor to the environment ministry and regulators on all issues concerning nuclear waste management.

Sweden does not intend to reprocess spent fuel. At present, all spent fuel is shipped to an interim store, CLAB, situated adjacent to the reactor site at Oskarshamn. Fuel is planned to spend at least 40 years at CLAB before being transferred to a final repository when constructed. Spent fuel will be encapsulated prior to disposal.

In 1983, SKB presented the "KBS-3 Report", describing a disposal concept for Swedish spent fuel. This still remains the basic reference design. Under the original KBS-3, the repository would consist of a number of parallel tunnels at a depth of about 500 m, connected by a central tunnel for transportation and communication. Vertical holes with room for one canister in each were to be drilled from the floor of the tunnels. Copper canisters would then be emplaced and surrounded by compacted bentonite.

Potential sites for a repository have been under investigation in Sweden since 1977. Detailed investigations are proceeding at sites where local municipalities have volunteered participation, focussed on Östhammar and Oskarshamn. Site investigations are expected to finish in 2007. It is envisaged that permits will be granted to start construction at one of the sites by 2011, with disposal operations commencing in 2018. In 2007 a survey of local inhabitants showed that 77% of the population in Östhammar and 83% in Oskarshamn are in favour of an establishment in their own municipality.

4.1.10 United Kingdom

After a relatively short period of storage at the reactor site, spent fuel is transferred, with exception of Sizewell B, to the Sellafield plant in Cumbria for reprocessing or long-term storage. Vitrified HLW arising from reprocessing is stored in surface storage for decay cooling pending eventual final disposal after a period of at least 50 years.

Since the formation of Nirex (Nuclear Industry Radioactive Waste Executive) in the early 1980s, the main focus on geological disposal in the United Kingdom has been in relation to intermediate and long-lived low level wastes. However, Nirex proposals for an underground research laboratory in Cumbria were rejected by the government in 1998. In 2001 a national consultation began to address methods of management for all long-lived solid radioactive wastes. A Committee on Radioactive Waste Management (CoRWM) was established to examine a list of options and recommend a way forward. Following a process of extensive public consultation, CoRWM published its final report in July 2006, recommending deep geological disposal as the best approach in terms of both safety and security. CoRWM also recommended that site selection should be pursued by means of a partnership arrangement with a voluntary, willing, community, which would be compensated for its participation. This would take account of the Swedish and Finish experience. In the meantime, CoRWM believes that a robust programme of interim storage is needed to safeguard the waste for 100 years or more, in case of delay or failure in a repository programme.

In October 2006 the government confirmed that long-lived radioactive wastes will be disposed of in a deep geological repository as proposed, accepting CoRWM's recommendations for implementation, subject to a short public review. It has given responsibility for developing a programme to implement the strategy to the recently established Nuclear Decommissioning Authority, which has absorbed the functions of Nirex.

The timescale for implementation of the proposals needs to be flexible, but it is expected to take in the order of 30 years before the first emplacement of waste can begin.

4.1.11 The United States

For many years, civilian and defense-related activities have produced spent nuclear fuel and high-level radioactive waste. These materials have accumulated, and continue to accumulate, at 72 commercial and 4 U.S. Department of Energy (DOE) sites across the United States. Because these materials are highly radioactive, they must be isolated from the accessible environment.

More than 25 years ago, the Congress adopted the *Nuclear Waste Policy Act of 1982* (NWPA) which created a comprehensive national program for the safe, permanent disposal of highly radioactive waste in a geologic repository. This program included the identification, characterization, and approval of a site for a permanent geologic repository, and for its licensing by the U.S. Nuclear Regulatory Commission (NRC). The NWPA assigned lead responsibility to the Secretary of Energy and created the Office of Civilian Radioactive Waste Management (OCRWM) to develop and manage a federal system for disposing of commercial spent nuclear fuel and defense high-level radioactive waste.

After DOE considered nine sites and recommended three for detailed site characterisation, Congress amended the NWPA in 1987 and selected Yucca Mountain as the single site for further study.

In February 2002, the Secretary sent to the President his recommendation for approval of the Yucca Mountain site for development of a geologic repository. The President considered the site qualified for application to the NRC for construction authorisation and recommended the site. Subsequently, Congress passed a joint resolution of the House of Representatives and the Senate designating the Yucca Mountain site for development as a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste. In July 2002, the President signed the joint resolution into law. DOE is now in the process of preparing an application for submittal to the NRC seeking authorisation to construct the repository. The license application is expected to be submitted in 2008.

OCRWM has continued to develop the repository design and associated construction and operational plans. As now designed, the surface and subsurface facilities would allow DOE to operate the repository following a primarily canistered approach in which most commercial spent nuclear fuel would be packaged at the reactor sites in transportation, aging, and disposal canisters. DOE would construct the surface and subsurface facilities over a period of several years (referred to as phased construction) to accommodate an increase in spent nuclear fuel and high-level radioactive waste receipt rates as repository operational capability reaches its design capacity.

4.2 Some examples of practical experience

As a further input to this study, five of the countries involved (Belgium, Czech Republic, France, Germany and Japan) provided additional information on their HLW disposal programmes and on their experience in implementation. The table in Appendix 5 provides a summary. From this additional information, the following observations can be made:

- Three of those countries began their HLW disposal investigations some considerable time ago (1960s and 1970s); two countries began their investigations relatively recently (early 1990s).
- Despite this, the anticipated times for the start of construction are very similar, one country expecting this to be 2015 and the other four, around 2025.
- Those countries beginning their programmes relatively recently still expect 35-70 years of work ahead of them before their repositories are operating.
- It is clear that those countries starting relatively recently have learned valuable lessons from the experience of others. In particular they have aimed at establishing key features early in their work:
  - The legal framework.

- The decision-making process.
  - The criteria for acceptability.
  - The engagement of the public in the process.
  - The need for volunteer communities.

- All five countries have or are in the process of taking steps to identify the issues of concern raised by the public. The German information identifies explicitly that these include fear of loss of status and economic value to the region and at a personal level if a repository is constructed in their locality (fear of stigmatisation as the "repository region" and fear of loss of real estate value etc.). While a number of countries have considered some form of "compensatory measures" to alleviate these concerns and to compensate a community for hosting a repository, explicit measures are already in place in the five countries in Appendix 5. Examples of compensatory approach can be:

  - The 2006 Planning Act in France defined the Public Interest Group (GIP) which is in charge of the economic development of territories with relevant resources allocated in priority, to a proximity area.
  - Hungary (which did not participate in the Expert Group), where such compensation is established in law.[1]

- It is apparent from this study and the extensive work of the RWMC that there are a large number of factors impacting on the decisions about siting and timing of a repository [1,7]. It is also clear that transparency in decision making is a key factor in making progress. Despite this, there appears to be very limited use of such decision-making aids as multi-attribute decision analysis. This observation is explored further in Chapter 6.

1. Act CXVI of 1996 on Atomic Energy last amended in 2005.

Chapter 5

ASSESSMENT OF FACTORS

A more detailed description of the factors influencing timing, as identified in Chapter 2, is developed in the following chapter.

5.1 Technical factors

There is a large range of technical factors [40] which need research activities and optimisation before operation of a repository for HLW can start. Some countries, e.g. France and Sweden, are already well advanced in demonstrating the technical feasibility of HLW disposal. By contrast, virtually no government-funded R&D on HLW has been carried out in some other countries for over twenty years. The research and optimisation work might differ in different countries based on the chosen strategy, timeframes and national organisational framework.

Technical factors such as thermal loading influence the dimensions of and the area for the repository, although this can be managed by extending the interim storage (cooling) period [25]. It follows that there can be a trade-off between repository design and the timescale for disposal.

5.1.1 Prospective HLW arisings

The generation of spent fuel over the lifetime of existing nuclear power plants is well known. Table 5.1 shows the installed nuclear capacity and arisings of spent fuel for various OECD countries.

In general, the volumes of HLW generated by nuclear power plants are relatively small in comparison with other dangerous wastes generated in society [33]. Unfortunately, data from the Eurobarometer 2005 Report show that this is not widely appreciated, at least by the European public (cf. Chapter 3, Figure 3.5).

5.1.2 Heat production and interim storage

Interim storage is needed to allow the levels of radioactivity and heat output to decline before the next step or process of the waste management strategy can be undertaken. Short-lived radionuclides must be allowed to decay so that the heat output and radioactivity are reduced to a level at which the SNF can be safely transported and, if so decided, reprocessed. In most cases, this initial storage will be under water in cooling ponds at the reactor site, typically for periods of months to several years.

Other reasons to create interim storage could be to provide stock for an ongoing process, transport step or immediate disposal, awaiting a step for which the required facility or transportation capability is not yet available, or awaiting a decision to be made on the next step for a particular waste or material; for materials that, while not immediately required, have some potential future use or value and, therefore, have not been declared as a waste [1].

Table 5.1 Spent fuel arisings and cumulative in storage in 2006 [10]

Country	Installed nuclear capacity (GWe)	Arisings *(tonnes of HM/year)*	In storage *(tonnes of HM)*
OECD America	113.9	3 915	91 465
Canada	12.5	1 587	36 912
Mexico	1.4	22	427
United States	100.0	2 306	54 126
OECD Europe	131.6	3 022	29 583
Belgium	5.8	134	2 478
Czech Republic	3.5	69	1 033
Finland	2.7	67	1 510
France	63.3	1 100	10 170
Germany	20.3	410	4 160
Hungary	1.8	44	1 138
Italy	0.0	0	237
Netherlands	0.4	12	485
Slovak Republic	2.4	51	1 131
Spain	7.3	128	3 497
Sweden	9.0	310	4 598
Switzerland	3.2	68	924
United Kingdom	11.9	630	393
OECD Pacific	63.9	1 670	20 964
Japan	47.1	960	12 294
Korea	16.8	710	8 670
Total	**309.4**	**8 607**	**142 012**

There are some examples where it is planned to keep vitrified HLW and/or SNF in interim storage facilities for 50-70 years from the end of operation of the nuclear power reactors until the disposal starts. There are other examples of 30-50 years of interim storage for the cooling of vitrified HLW prior to final disposal. As noted above, there can be a trade-off between cooling period and repository design which influences the timing of disposal.

Long-lived solid radioactive waste and spent nuclear fuel have been safely and securely stored in OECD member countries now for several decades. Such storage could continue for many more decades, given proper controls and supervision combined with repackaging of some wastes and periodic refurbishment of stores [1]. However, this can only be an interim solution; at some point a final disposal solution must be implemented.

Packaging requirements – some examples

In Canada, dry storage containment at reactor sites would consist of the existing casks, vaults and silos. For disposal, facilities would exist at a central site for repackaging the used fuel. Storage containers at the envisaged central storage facility would be based on the existing design of the dry storage container or equivalent with a 100-year design life. By contrast, containers for long-term isolation in a deep repository can be expected to maintain their integrity for up to 100 000 years in a well-designed deep geological repository where chemically reducing conditions significantly slow corrosion processes. These durable containers combined with the repository environment form a system that is designed to withstand long-term effects such as climate change and glaciation. Further container development is needed and performance for the total design lifetime also has to be demonstrated for normal and off-normal conditions.

In the Czech Republic, SNF is currently stored in dry store using containers, which are licensed by the State Office for Nuclear Safety for 10 years. After 10 years, it is possible to prolong the licence on the basis of tests. These containers are designed for 60 years. However, lifetime extension of the containers is under investigation. Repackaging of SNF for the storage time period is planned in the HLW disposal strategy. For SNF the main option is direct disposal (but partitioning and transmutation is also under consideration).

Definitive waste acceptance criteria (WAC) for the geological disposal of ILW/HLW will only be possible when a repository is fully specified and licensed. In Belgium the present WAC are essentially based on the transport and long-term storage requirements and limitations, and on the provisional disposal concept and the associated safety analysis. For example, the present disposal concept envisages that a number of categories of waste will be repackaged in standardised "waste disposal units" at the time of their transfer to the disposal facility. The associated repackaging costs are already being taken into account in the calculation of the financial provisions.

Longevity of fuel integrity

The longevity of the SNF integrity is a component in the safety analysis for interim storage facilities as well as for final repositories. However, in the country reports prepared for this study the initial integrity of spent fuel is not considered to have a high impact on timing of HLW disposal.

The safety analysis performed by ONDRAF/NIRAS in Belgium considers that it is not needed to guarantee the integrity of the spent fuel itself following emplacement in the repository. The system, consisting of the conditioned SNF, the multiple-barrier system between the waste and the host-rock, and the retention properties of the clay host-rock itself are sufficient to provide the necessary level of protection. The analysis proved that for the demonstration of long-term safety, no account need be taken of fuel clad integrity and that the radionuclides can be considered "available for migration" [2].

Longevity of interim storage facilities – some examples

In Canada, the expected lifetime for interim storage is between 100 and 300 years. In the case of extended interim storage, the storage facilities would need to be refurbished or replaced about every 300 years (see Appendix 3).

In Germany, interim storage facilities which have been constructed at the NPP sites for SNF have licences for only 40 years of operation. This restraint imposes a strict time limitation for interim storage, which maintains the pressure to site the final radioactive waste disposal facility.

In the Czech Republic, NPP operators keep SNF in wet storage for 7 years in the Dukovany NPP and for 12 years in Temelín NPP. After these time periods SNF is stored in dry storage in metallic containers, with the current design life of 60 years, until their final disposal.

5.1.3 Suitable host rocks

Essentially any type of rock formation is expected to be potentially suitable as a host formation for radioactive waste disposal. Table 5.2 summarises the types of host rock which have been investigated under various national programmes. Salt formations are capable of accepting higher temperatures than clay. It follows that the difference between the interim storage periods for the necessary cooling in salt and in clay formations has to be considered in the planning process. Crystalline, salt and sedimentary host formation types are well represented in this study. Igneous rock has been chosen by the United States for its Yucca Mountain site. What matters is the specific context of the geology of an individual site. The design of a disposal facility permits a certain degree of flexibility within the limits of the characteristics of the geological formation.

In Germany, an overall site selection screening process was completed in 2005, covering several technical and conceptual questions. The conclusion was that there is no superior host rock type and that the safety potential of any site is mainly determined by its individual features and properties. Site selection criteria for saline, granite and argillaceous host rock media will now further be revised. With these criteria, a new site selection process for the German HLW repository will be initiated.

Spain stopped its research on potential host rocks in 1996.

5.1.4 Number of suitable host rocks and/or candidate sites

Experience demonstrates that the number of considered host sites may vary from a few, up to hundreds in different stages in the stepwise site screening process. That means availability of suitable host formations is generally not a limiting factor for timing of HLW disposal.

As such, the start of the site selection process (in larger countries which offer a range of host rock types) may involve more than one host rock formation and a relatively large number of sites. As more knowledge is acquired during the subsequent stages of site selection process, the search gradually narrows to focus on a smaller number of sites to which increasingly specific criteria are applied. Site selection might be a very time-consuming process. Although interim phases of the site screening processes target two up to six host geological formations, it is common among the countries participating in this study for the final goal to be one or maximum two options for the HLW disposal site.

Table 5.2. Host formations for potential geological disposal under investigation in OECD member countries

Country	Host formations under investigation
Belgium	Boom clay
Canada	Crystalline and sedimentary rocks
France	Clay (now preferred), granite (research has ceased)
Czech Republic	Granite
Republic of Korea	Granite
Japan	Crystalline and sedimentary rocks
Germany	Salt, clay, granite
Spain	Clay and granite
Switzerland	Crystalline and Opalinus clay
Finland	Granite
Hungary	Clay
Netherlands	Salt and clay
Slovak Republic	Crystalline and sedimentary rocks
Sweden	Crystalline bedrock
United States	Volcanic tuff – Yucca Mountain Salt – WIPP (already operational for TRU defence waste)

Site specific properties are only known after completion of a rigorous site investigation process. The current practice is based on a stepwise screening methodology that calls for increasingly concentrating steady investment and that, from a technical point of view, includes:

- area-specific literature surveys focusing on the long-term stability of the geological environment followed by a down selection;
- detailed investigation of the limited number of candidate areas selected from the literature survey through surface-based investigations to evaluate the characteristics of the geological environment;
- detailed site characterisation after the final site selection, including underground experimental facilities.

The final decision on a disposal site is always the result of extensive research on the properties of the suggested host rock formation(s), the technical qualification programme and the consultation process with relevant stakeholders. The approach for performing investigations of HLW disposal sites might be different in different countries. This will involve balancing the following factors:

- the economics of long-term research;
- the availability of resources;
- the related process for public confidence building; and
- extended decision-making processes, probably over decades, where all options are kept open.

It has proved useful to demonstrate that several options are open for discussion in the early phase of the consultation process. To have early open and transparent communication processes ongoing at several sites at the same time is resource demanding, but might also give advantages for the public to participate and benefit from the consultation process at the different sites. This might improve the understanding of the problems and the proposed technical solutions and give an opportunity to exchange views on different issues related to HLW disposal. Premature selection and focus on one or two sites could lead to failure (for either technical, economic or socio-political reasons) and result in nugatory work and significant delay whilst the process is restarted.

It is, however, always easier to concentrate the efforts on exploration and investigation to a limited number of potential HLW disposal sites. Splitting economic resources, technical capabilities (equipment and human resources), and resources for public consultation on a number of different sites might cause difficulties, especially in small nuclear programmes.

Where a country has chosen a host formation and a site, and the properties of the existing explored site are deemed to be favourable, seeking a second or third site may not appear to be a priority. However, if positions on the acceptability of the chosen site diverge, the need for a backup solution will arise. From the technical point of view it might be possible that alternative sites in the same formation can be found without extensive investigation and growing expenditures (for example data from an underground research laboratory might still be relevant).

In an open society the final selection of a site will sooner or later be challenged and scrutinised by the stakeholders from every possible angle. Strong arguments must be available to show that the final choice has been made on the basis of a rigorous and transparent selection process which takes account of safety, technical, economic and social factors and criteria. An extensive background material will give a solid basis for the arguments in this discussion.

5.1.5 Transportation of HLW

The operation of a waste disposal facility involves transporting the HLW (i.e. SNF or vitrified HLW) from existing waste generators (nuclear power plants or reprocessing plants) to centralised or decentralised interim storage facilities over a certain time period and then subsequent transport to the final disposal site. The mode of transportation (road, rail or water) will depend on the location of the interim and final facilities.

The strategy for interim storage of HLW (centralised or decentralised) will have a large impact on the routes and timing of HLW transports. Public acceptance in communities along transportation route(s) of HLW might influence transport times, however no long-term effects on timing of HLW disposal are expected. Transport times for centralised HLW management solutions are expected to be relatively small in comparison with the timescales of closing the fuel cycle.

Depending on the size of the country and the size of the country's nuclear energy programme, theoretically there could be several technical solutions for the HLW disposal:

- final disposal at the site of waste generation (SNF at reactor sites, vitrified HLW at reprocessing sites), assuming the availability of suitable host geological formation;
- one centralised HLW disposal facility;
- more than one centralised HLW disposal facility; and
- other solutions are regional HLW disposal or international centralised facility.

In the first case HLW is kept inside or near the waste generator's boundaries with no significant need for off-site transport.

Challenges raised by transportation of HLW have to be considered; including establishment of a regulatory framework, lead-time to design and procure casks, environmental impact analysis, infrastructure-adaptation requirements (rail, road, etc.) and emergency response planning. Communities along the transportation route(s) might be expected to be concerned about the added risks. Although these risks are very low and exposure of the public to them is very transient, that is not the public perception.

For all countries planning HLW disposal, the inventory of SNF generated during the whole operational cycle can be predicted precisely. Based on the disposal concept and given the transport modes and routes, the number of shipments and the time needed can be calculated with a high level of certainty. For countries with large territories and a distributed nuclear reactor fleet, the costs of transport might differ considerably, depending on the HLW disposal siting strategy. A Canadian radioactive waste management study completed by the Nuclear Waste Management Organization (NWMO) considers this issue in some detail.

In general the distance of repository sites from the waste generators might have only minor influence on timing of HLW disposal, but transport of even low-level radioactive waste currently is an issue of public concern, as is indicated by the results of the *Special Eurobarometer 227 – Report* (cf. Figure 3.4). Transport is also vulnerable to disruption by political demonstrators.

5.1.6 Regulatory standards

In the country reports, dose criteria were not considered as relevant factors for the timing of HLW disposal. Additional shielding around the drums can efficiently protect the operators against the ionising radiation. This shielding can be reusable if just for handling purposes or disposed of with the waste forms, so dose does not present a significant issue. On the other hand heat generation has been noted as having a high impact on timing. Whatever the decay and cooling time needed, or decided, before waste emplacement in the deep repository, evaluation of radiological safety is an important factor for the implementation of HLW repositories and their design. If for any reason (e.g. industrial and/or financial strategy) a relatively short decay and cooling time is decided, evaluation could become an important planning factor as well.

5.1.7 R&D

R&D on the disposal system

All countries with a HLW disposal programme are performing extensive basic geological research on suitable host rock formations and principles for possible disposal systems. The aim is to provide the necessary data for assessing the feasibility of a deep geological waste repository. This means comparing theoretical repository concepts with the particular conditions encountered in clearly defined geological sites, and demonstrating their safety over the very long term. The repository concepts studied are based on the multiple-barrier principle. The barriers are: the waste package (the waste and the material used to stabilise it in a suitable overpack), the engineered barrier inserted between the waste package and the rock, and the geological barrier, i.e. the actual rock. Site characteristics are first studied from the surface, then *in situ* in an underground research laboratory.

In France, issues suggested for further research by independent reviews are:

- radionuclide migration within the rock, with particular emphasis on the study of issues associated with the variability assessment of rock properties at various scales;
- the future of corrosive gases within the repository and, especially, their impact on the re-saturation phase of the repository;
- the efficiency of the plugs in relation to the long-term evolution of the excavation disturbed zone (EDZ);
- further development and benchmarking of hydro-geological models;
- diffusion experiments over long timescales;
- the need for technological demonstrations in order to validate concepts.

For all countries it might take several decades to reach the knowledge base and optimisation level needed, which will certainly influence timing of HLW disposal. The multi-barrier principle is planned in all countries with nuclear disposal programmes. A disposal system, comprising a site, civil works and waste packages, each contributing to the functions required to ensure safety, can be designed to ensure safety over both the short and the long term. Political or technical decisions on narrowing the research field to one or a few suitable rock media types will strongly influence the time needed for the basic research.

In countries where government decisions have been taken to phase out nuclear energy it is especially important that the necessary economic resources for R&D be allocated as well as that human knowledge and skills be maintained, in order for timely implementation of actions for HLW disposal systems.

From the feedback from the countries participating in this study, two areas in the RWM strategy have been specially recognised as important from the viewpoint of the societal decision-making process:

- Demonstration and verification of the performance of different repository components in advance of the repository operation are intended to provide the public with assurance that the repository will remain safe in the long term, protecting future generations.
- It is widely helpful if a deep geological disposal repository is designed to incorporate the principle of reversibility to give future generations the freedom to make other choices regarding management.

If these issues are addressed so as to increase public acceptability of geological disposal, then it follows that the timescale for implementation can be significantly reduced.

Applied R&D

There are a number of underground laboratories in operation around the world which generate substantial technical information and data in support of current and future decision making. *In situ* research of the potential host-rock formations for HLW disposal is a very important phase of the site selection process from technical, economic and social points of view and therefore also impacts the timing of the HLW disposal system.

In France, ANDRA has studied the feasibility of an HLW repository in French clay and granite formations for fifteen years. The results of this research are presented in the *Dossier 2005 Argile* (clay) and *Dossier 2005 Granite*.[1]

In Germany, underground research started in the late 1960s in a disused salt mine. The current HLW management strategy foresees operation of underground laboratories until 2030, when the site selection process is to be concluded.

In Belgium, the R&D programme on the Boom-clay layer started in 1974 and the HADES underground research laboratory has been in operation since 1984. The research involves technical as well as societal aspects of sustainable management of radioactive wastes.[2] Heat generating waste is classified as a separate waste stream. To investigate the effect of heat production in possible host geology formations the PRACLAY experimental work has been launched in addition to a very large number of tests which have already been performed and their results published. Belgium plans to publish a preliminary safety assessment report of a reference solution by 2025. Based on the research programme, integrated sets of arguments called "safety and feasibility cases" (SFCs) are to be published in 2013 and 2020 [21].

The current tendency is towards increased comparison and integration of social and economic issues with the technical aspects. A close interaction of a stepwise research and development programme and societal dialogue may help improve confidence in predictions and improve public confidence in the national radioactive waste disposal programme. A successful stakeholder involvement programme is crucial for the timing of HLW disposal implementation. For example, under Canada's Nuclear Fuel Waste Act (NFWA), a new Nuclear Waste Management Organization (NWMO) was established in 2002 and has recommended a "phased adaptive" approach for the long-term management of nuclear fuel waste. This is defined as "the process of conceiving and carrying out a programme as an experiment, so that learning from experience becomes an explicit objective. An adaptive approach to nuclear waste management may enable NWMO to build and sustain public trust while accelerating technical progress." The revised strategy foresees the need for further research in underground laboratories as part of a site selection process [6].

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1. http://www.andra.fr/publication/produit/

2. B. Neerdael, J.P. Boyazis (1997), "The Belgium underground research facility: Status on the demonstration issues for radioactive waste disposal in clay", *Nuclear Engineering International*, Vol. 176, No. 1, 3 November 1997, pp. 89-96, Elsevier.

R&D on new and/or innovative technologies

Waste minimisation techniques might be effective when considering a future waste management system and its implementation in a reasonable timeframe. Use of fast reactors to reduce HLW is a new aspect in current national energy strategies that requires special attention in public communication. In some countries basic R&D programmes on partitioning and transmutation (P&T) are therefore seen by some experts as a means to reduce the burden for implementing HLW disposal and, therefore, to improve public acceptance. This is one of the reasons why the European Commission also supported research work on partitioning and transmutation of radioactive waste under the 4th, 5th 6th and 7th Framework Programmes since 1994 [23].

However, the possibility of separating and transmuting various radioactive isotopes has only been demonstrated at laboratory scale. There is a view that P&T of long lived radionuclides cannot be applied industrially before 2040-2050, will still leave residual HLW waste, and will not be feasible for existing conditioned waste because of the difficulty and cost of reworking such waste. Opinions are currently divergent regarding the importance and the future role of P&T.

In Germany P&T is seen as an important technical development for improving public acceptance in the future.

In France, the *Commissariat à l'énergie atomique* (CEA) has been charged with carrying out research into partitioning and transmutation as a possible means of reducing the radiotoxicity of HLW, particularly in the context of a fast reactor fuel cycle. Following a recent publication, "2005 Report: Partitioning and Transmutation", the French Government requested the OECD/NEA to organise an international peer review of that study [22].

Canada considers that the introduction of partitioning and transmutation on a commercial scale would require an additional process step at the back-end of the nuclear fuel cycle and a commitment to the continued use of nuclear energy by current and future generations. The use of P&T would increase the risk for radiation exposures due to the increased complexity of the fuel cycle and the multiple processing steps involved in partitioning and transmutation [6].[3] However, the NWMO recommends keeping a "watching brief" on the findings in the area.

The Czech Republic monitors partitioning and transmutation of spent nuclear fuel as an open option. Some basic studies concerning vitrified waste have been elaborated in this connection as well.

In the European Union it is widely accepted that some of the present waste forms will not be further processed and, even if partitioning and transmutation becomes technically feasible and economically attractive, it would still leave a high-level waste stream that would need to be disposed of. This is clearly stated in the "Nuclear Illustrative Programme" published in January 2007 [27]. The directive proposed by the European Commission on "The management of spent nuclear fuel and radioactive waste" does strongly encourage progress on geological disposal, but it also advocates research, emphasising new technologies that would result in less radioactive waste and smaller volumes.

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3. www.nwmo.ca

5.1.8 International collaboration and experience

There are many types of international cooperation, for example, bilateral or multilateral agreements on experience and information exchange, common international projects, co-ordinated research programmes, international expert reviews, etc. International collaboration is very important in, for example, testing methods for the assessment of repository safety, defining criteria for technical acceptability, demonstrating feasibility of deep geological repositories, conducting research and in developing new technologies and technical databases.

The country reports provided for this study demonstrate examples of the importance of the international cooperation work:

- In the Japanese report the following projects were noted as efficient and successful international projects with high importance for the Japanese HLW programme: the Stripa project in Sweden, NEA Thermochemical Database Project, the Äspö Hard Rock Laboratory Project in Sweden and the Mont Terri Project in Switzerland.
- In the Czech Republic, the Radioactive Waste Repository Authority (RAWRA) is involved in international collaboration for research on HLW disposal. These include: coordinated research projects with the IAEA; NEA joint projects and experience exchange in the Radioactive Waste Management Committee (RWMC), the Integration Group for the Safety Case (IGSC) and the Forum on Stakeholder Confidence (FSC); and collaboration and research for the EU Framework Programmes (FP5 and FP6). These were recognised as useful frameworks to improve experts' technical knowledge on HLW disposal issues. Bilateral collaboration of Czech research institutions supported by RAWRA is also wide. GRS (Germany), SKB (Sweden), Posiva (Finland), NAGRA (Switzerland), ITC (Switzerland) and ONDRAF/NIRAS (Belgium) are partners in bilateral research.
- In addition to independent technical reviews by the National Review Board and the Nuclear Safety Authority, the French *Dossier Argile* 2005 for clay formations was subjected to an international expert review organised by the OECD/NEA.
- Belgium also invited an independent international peer review for its RWM programme by the OECD/NEA. That review provided some guidance for the future research activities.

Other examples for international cooperation to demonstrate the feasibility of HLW disposal are:

- The Tunnel Sealing Experiment in Canada's Underground Research Laboratory, which was jointly supported by Atomic Energy of Canada Limited (AECL), Japan Nuclear Cycle Development Institute (JNC) and *Agence nationale pour la gestion des déchets radioactifs* (Andra).
- The International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM), to enhance international cooperation by exchanging views on policy issues and to stimulate joint research and development projects. Its 12 members are senior level officials who are responsible for waste management programmes in 11 nations.
- The multinational projects on "Development of coupled models and their validation against experiments in nuclear waste isolation" (DECOVALEX I-III) focused on coupled thermal, hydrologic, mechanical, and chemical processes of importance to radionuclide release and transport, and provided an opportunity for peer review for code developers along with the exchange of laboratory and field data for validation purposes.

- The OECD/NEA International Project of the Transport of Radionuclides in Heterogeneous Geologic Media (GEOTRAP), a venue for exchanging information on approaches for acquiring field data, testing, and modelling transport of radionuclides in geologic formations.
- The European collaboration project on the "Impact of Partitioning, Transmutation and Waste Reduction Technologies on the Final Waste Disposal" (RED IMPACT).

International experience is that failures in siting programmes worldwide are more often due to societal than to technical issues. Lessons learnt through international exchange of experience on societal issues and public communication and dialogue issues are of particular help in developing HLW disposal programmes. There are several forums for exchange of information of this nature, such as the Forum on Stakeholder Confidence hosted by the OECD/NEA.

International organisations such as IAEA and OECD/NEA provide a joint platform for effective and intensive collaboration and offer different services to improve information and experience exchange. International cooperation is deemed to have an important impact on the timing of implementation of relevant systems for HLW disposal.

5.1.9 Availability of knowledge and national expertise

One important drawback of postponing HLW disposal is the problem with long-term knowledge preservation. Both the technical and human aspects should be considered here. It is crucial that the long-term availability of highly qualified and trained staff, for all phases of the implementation of HLW disposal systems, is carefully planned. The knowledge base developed by the implementers as well as by regulators and research institutions should be secured. The timing of HLW disposal programmes may be severely impacted if the knowledge transfer chain is broken between the generations involved.

A good example where these issues have been systematically dealt with is the Czech Republic, where the human aspect of knowledge preservation is ensured by duplication of some positions in project teams and also by extensive teamwork where senior and young scientists work together. There is also a requirement for the relevant documentation to be kept in duplicates physically at several places. Hard copies of geological reports are to be filed in the central archive of the Czech Geological Survey according to the Geological Act. Relevant data are filed in protected databases as well.

5.2 Socio-political factors

5.2.1 Importance of the nuclear programme

Since the share of nuclear electricity production compared with the total electricity production and total electricity generating capacity reflects the respective national importance of nuclear programmes, and hence the relative importance of HLW disposal, it is interesting to compare data on nuclear power production (Table 5.3).

Indicators presented in the table show the level of reliance on nuclear power reactors in different countries. Nuclear power reactors are preferably used in base load operating mode for technical reasons and the reasons of efficiency and cost-effectiveness. Hence the nuclear share based on the energy produced is always higher than the nuclear share of the installed generating capacities.

Table 5.3 Comparison of indicators reflecting on the importance of a nuclear programme

(2005 data)	Number of reactors	Nuclear electricity production (TWh)	Installed nuclear electricity generating capacity (GWe)	Nuclear share of production (P) (%)	Nuclear share of capacity (C) (%)	P/C
Belgium	7	45.3	5.8	54.3	36.0	1.51
Canada	20	86.7	12.5	14.5	11.1	1.31
Czech Republic	6	23.3	3.5	30.6	21.3	1.44
Finland	4	22.4	2.7	33.0	19.7	**1.68**
France	59	430.0	63.4	78.2	54.7	1.43
Germany	17	154.0	20.3	26.6	15.2	**1.75**
Japan	55	291.9	47.1	31.7	20.8	1.52
Hungary	4	13.0	1.8	39.5	22.5	**1.76**
Rep. of Korea	20	138.7	16.8	40.1	28.4	1.41
Mexico	2	10.8	1.4	4.9	2.5	**1.96**
Netherlands	1	3.3	0.4	2.9	2.1	1.38
Slovak Republic	6	16.3	2.4	56.2	31.2	**1.80**
Spain	8	55.4	7.5	19.8	10.0	**1.98**
Sweden	10	69.5	9.2	45.0	27.7	1.62
Switzerland	5	22.0	3.2	38.0	18.7	**2.03**
United Kingdom	19	75.2	11.9	20.4	15.3	1.33
United States	104	782.0	100.0	19.3	10.2	**1.89**

In countries where the nuclear programme is significant, it might be expected that the HLW issue would also be high on the political agenda. However, this study was unable to find any significant correlation between the timing for HLW disposal and the size of the nuclear power contribution in a given country from the data in this table. Radioactive waste needs to be safely managed and disposed of whatever the size and relative importance of nuclear production.

5.2.2 Legal framework

A strong and stable legislative framework, where the disposal of HLW is an integral part of the country's energy strategy, will have a high impact on the timing of a HLW disposal system.

A good example of this is Finland, where the law excludes any possibility of exporting or importing nuclear waste from or to Finland. As early as 1983 the Finnish government made a decision regarding HLW waste management including a detailed time schedule for its implementation. In accordance with this schedule, in 2000, the Finnish government made a "decision in principle" on the construction of the final disposal facility with the agreement of the local population.

Other examples of programmes where legislation has had an important influence on the timing and where the site selection process has advanced are Sweden and France. In France, the legal framework for the time period between 1991 and 2006 was supplied by the 1991 law on radioactive waste management. A new law was passed in 2006 to cover future activities on the subject.

However, in most countries the site selection process has so far been less successful, and is the central time consuming issue in the process of implementation of a HLW disposal system [27]. In the legislative framework the environmental assessment is an important input item for the technical decision-making process. In many countries the environmental impact assessment work also calls for a high degree of public consultation on the selection and assessment of options, which contributes to confidence building and thereby the possibility for timely implementation.

The European legislation imposes Environmental Impact Studies (85/337/EEC as amended by 97/11/EC) and Strategic Environmental Assessments (2001/42/EC) which are applicable to HLW disposal as well. The Environmental Impact Studies are primarily aimed as much for assessing impacts as they are for informing the public.

5.2.3 Continuity and stability of the decision-making process

The structure of the decision-making process, the involved actors and their roles and the public perception of this process and the possibilities to participate, are important factors for a timely and successful implementation of a HLW disposal system.

The general political climate regarding nuclear issues and the political stability of keeping to previous decisions on principles and time schedules will also influence the views of the general public and their confidence in the decision-making process. If this stability is lacking, expert input and communication programmes might have little effect.

The stability of the decision-making process has been discussed in the NEA Forum on Stakeholder Confidence (FSC). In a document on "Stepwise Approach to Decision Making for Long-term Radioactive Waste Management" [7] it is noted that "Discrete, easily overviewed steps facilitate the traceability of waste management decisions, allow feedback from regulators and the public, and promote the strengthening of public and political confidence. They also allow time to build trust in the competence of the decision makers as well as the implementers of a waste management project."

This issue has particular relevance to long term storage of HLW. In the recent NEA publication "*The Roles of Storage in the Management of Long-lived Radioactive Waste*" [1] it is stated that "... safe and secure storage will depend on continued political and societal commitment and also national economic stability to maintain the responsible organisations and resources. Such factors become harder to guarantee the further into the future that is considered. Therefore, regardless of the reasons why long-term storage is initiated, assessments of its future safety are based on assumptions concerning future economic, political and societal continuity and stability – which introduce large and unpredictable uncertainties into the prospects of future safety and security."

While it might be politically convenient to defer decisions on radioactive waste disposal, this is not sustainable in the long-term. The Eurobarometer data shows clearly, that the public would like a resolution of the issue now, but that they understand the political difficulty of achieving this (cf. Chapter 3).

5.2.4 Waste ownership and responsibilities

With respect to future generations, it is the responsibility of governments to establish and enforce regulations related to radioactive waste management such that actions are undertaken to ensure that the environment is not unduly affected. Governments also regulate the ownership of SNF and HLW management. In many countries the state itself, either directly or through some type of participation in a company, is involved in disposal activities [24].

In the country reports provided for this study several different approaches regarding the legal ownership of SNF can be distinguished.

In Canada, there are currently four major SNF owners. They are responsible for establishing funds to finance the implementation of the long-term management approach selected by the government and establishing and maintaining a nuclear waste management organisation.

In Japan, the Atomic Energy Commission states that the operator of the facility that produces waste has the primary responsibility for safe processing and disposal of the waste. The government has the responsibility for taking necessary measures, through giving adequate guidance and setting necessary regulations, to ensure that this processing and disposal are carried out appropriately and safely by the producers. The government should play an appropriate role in implementing the disposal programme for radioactive waste, with a view to ensuring long-term safety, in addition to its activities related to promotion of research and development activities and safety regulation. The government controls the funds reserved for decommissioning of power plants, reprocessing spent fuel and for geological disposal of HLW. The Atomic Energy Commission decides on the basic waste management policy, while the Nuclear Safety Commission specifies the fundamental safety requirements.

In Germany, Belgium and the Republic of Korea, the legal ownership of HLW, as well as the safe management of radioactive waste, is the responsibility of the utilities. This responsibility might be held until the HLW is transferred into state owned central interim storage or in other cases until the state approves a sealed final HLW repository.

In the Czech Republic, the state is only responsible for HLW disposal once the operator of an NPP declares SNF to be radioactive waste, i.e. when it is not subject to reprocessing. Storage is the responsibility of the waste producers.

In Belgium, the acceptance of the waste and the transfer of property imply the transfer of financial means from the waste producer to ONDRAF/NIRAS. Similar mechanisms are implemented in the Czech Republic, Finland, the Republic of Korea, Sweden and the United States.

Country experience shows that, sooner or later, responsibility for HLW will be transferred from the waste producers to the state.

5.2.5 International constraints and opportunities

The IAEA "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management", the first legal instrument to directly address these issues on a global scale, was opened for signature in Vienna on 29 September 1997 [30]. The Joint Convention applies to spent fuel and radioactive waste resulting from civilian nuclear energy utilisation and applications, and to spent fuel and radioactive waste from military or defence programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes, or when declared as spent fuel or radioactive waste for the purpose of the Convention by the contracting party [30]. The Convention defines general safety requirements for spent fuel and radioactive waste management facility siting, design, construction, operation and spent fuel disposal. It also defines the roles and responsibilities of the regulator and the licensee and the general safety provisions.

Another important intergovernmental convention is the "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter". This instrument, generally known as the London Convention, was adopted in London in 1972 and came into force on 30 August 1975. The Convention has a global character, and contributes to the international control and prevention of marine pollution. It prohibits the dumping of certain hazardous materials, including low-level radioactive wastes starting from 20 February 1994.[4]

Several countries have already achieved significant progress in their own policy and programme for the management of HLW including disposal. Some countries have already chosen candidate sites for the disposal of HLW. On the other hand, for countries with relatively small quantities of waste there might be economic and technical advantages in pooling resources with one or more other countries to co-operate on development of multinational solutions for HLW disposal facilities. This might be an argument for postponing national waste management actions to wait for regional or international disposal options [1].

An international repository may become attractive for some countries in future years, but it must be a joint decision of all the countries in the region impacted by such a decision. However, given the difficulties experienced in establishing national repositories, multinational facilities do not appear to be a near term prospect. It will be important to continue to monitor developments in this area of radioactive waste management.

5.2.6 Security

Countries with nuclear programmes are currently focusing on risks related to proliferation and/or terrorism. The terrorism threat can not be neglected until the waste is placed in deep geological disposal. These factors are therefore important for the timing of HLW disposal.

The IAEA report on "Global Public Opinion on Nuclear Issues and the IAEA" [11] concluded that a majority of the population in 14 of the 18 countries surveyed believe that the risk of terrorist acts involving radioactive materials and nuclear facilities is high because of insufficient protection. To be able to meet the threats, governments have lately put effort into performing analytical assessments of the risks involved. This work is aiming at improved security at operating nuclear installations and as well improved proliferation resistance for the whole nuclear fuel cycle, starting from mining and conversion, through transport, and up to storage, conditioning and final waste disposal.

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4. http://www.imo.org/home.asp?topic_id=1488.

From the IAEA study, a majority of the population (about 54%) across all surveyed countries believe the risk of nuclear terrorism is high, while three in ten (28%) say that the risk is low. A Czech evaluation concluded that timing of HLW disposal will be influenced by the level of assessed risks from abnormal events at surface storage facilities. Terrorist attacks, earthquakes and plane crashes were considered as such abnormal events. If terrorist and proliferation risks are high on the political agenda, both factors may act as new drivers in the implementation of HLW disposal systems.

5.3 Economic factors

The availability of relevant funds at the right time for implementing a HLW disposal system is a critical timing factor. These funds will normally be built up during the operating life of the power plant.

5.3.1 Ethics

The objective of radioactive waste management, as given in the IAEA Principles of Radioactive Waste Management, is "to deal with radioactive waste in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generations" [43]. It is the view of most countries with operating nuclear power reactors that current generations should bear the responsibility for the radioactive waste generated. The general approach is that, according to the "polluter pays principle", the waste producers are responsible for supplying the financial means needed. This, in most cases, means collecting funds to cover the costs for the entire implementation of a HLW management system, from research to closure of the facilities needed through construction and operation.

Some countries have performed detailed evaluations of the impacts of long-term interim waste storage and have made statements on intergenerational responsibility which will influence the decision-making process, the HLW strategy and timing of HLW disposal.

In France, for example, the nuclear safety regulator (ASN) has pointedly observed that for long-term storage, above ground or just below ground, long-term safety would require continuous active monitoring. These kinds of actions cannot be guaranteed for more than a few hundred years, and might place an unacceptable burden on future generations.

From an ethical standpoint, the HLW strategy in France goes beyond intergenerational issues. In many instances principles of justice, equity and balance were requested by the public to be used, not only between generations, but also between territories. Local communities sharing the same geologically attractive formations want to share in the benefits as well as the disadvantages of siting the repository in their area. The new 2006 Planning Act provides the legal framework for the supporting mechanism to the economic development of the region in proximity of the research area.

In Germany, notwithstanding the current delay in the HLW repository programme, there has long been a consensus that a nuclear waste repository should be implemented as soon as possible, provided the safety requirements are met. This general consent between the majority of the public, the federal government, the political parties, the waste producers, and other groups involved still prevails and has never been seriously disputed.

All countries participating in this study are in some phase of a site selection process for HLW disposal. This is a clear sign of commitment by governments to take care of concerns related to intergenerational responsibility for HLW management.

5.3.2 Cost estimates and national practices

The economic risks in projecting the costs of a long-term and uncertain project such as an HLW repository are well known. The European Commission summarises this in the following statement: "The estimated shares of waste management and decommissioning costs are added to the price of electricity in the EU and deposited in special funds. However, because of the difficulty of predicting future costs, financing schemes need to be kept under review to ensure that adequate funding will be available when it is needed. [27]"

This difficulty in estimating the total lifetime cost is compounded by the strategic options available, for example whether spent fuel will be reprocessed (which in turn depends, inter alia, on the market price of uranium) or whether partitioning and transmutation (P&T) will become a practical reality.

It is not easy to find accessible sources of information on the economics for different HLW management options. Generally, however, the country reports show that cost evaluation of different HLW management strategies is a very important part of the decision-making process. It provides decision makers a good basis for making comparisons between the competing concepts. Governments put effort on proper management and economic viability of the selected waste management strategy to reduce the uncertainties related to and the economic risk of radioactive waste management.

The OECD/NEA study on *The Economics of the Nuclear Fuel Cycle* published in 1994 provided a comparison of undiscounted unit costs of encapsulation followed by direct disposal for three OECD/NEA members countries [26]. The lower and upper bounds in this study were 120 ECU/kgU and 500 ECU/kgU respectively. The study on *Projected Costs of Generating Electricity* that was published in 2005 [41] separately indicates the expected lower and upper bounds for unit costs of UOX fuel geological disposal and HLW disposal, that were 300 USD/kgUOX and 600 USD/kgUOX while these values are between 80 and 200 USD/kgUOX respectively for the vitrified HLW.

Cost evaluation by itself is rather complex given the long time periods and the uncertainties for such time periods. For example, the assessment of alternative options using a discounted cash flow approach depends on the choice of the discount rate. In a Canadian study of options, the most expensive option in undiscounted terms (continued above ground storage at nuclear reactor sites) became the lowest cost option when discounted at 5,75% (Table 5.4). Clearly, a high discount rate favours deferred expenditure. Other studies have tended to favour a low discount rate (1-2%) to reflect the large uncertainties inherent in making financial projections over very long periods.

One factor affecting the repository cost is the decision whether to reprocess or direct dispose of SNF. Japan has adopted a nuclear fuel cycle policy where vitrified HLW from reprocessing plants will be disposed of in a deep geological repository. The Japan Atomic Energy Commission has compared the costs of direct disposal of SNF and the disposal of vitrified waste. The comparison indicated that the range of costs for direct disposal of SNF was higher than that for the disposal of vitrified waste when Japanese geological environment and economic parameters are factored in. However, a total cost comparison is needed between direct disposal and nuclear fuel cycle to aid the decision about whether or not to continue the present policy [25].

Table 5.4 Total life cycle cost estimates for management approaches in the Canadian NWMO study

Management approach	Total cost (2002 BC$) (out to 350 years)	Total cost (2002 BC$) (out to 1 000 years)	Present value (Jan. 2004 BC$)
Option 1: Deep geological disposal in the Canadian shield	16.2	16.3	6.2
Option 2: Storage at nuclear reactor sites			
- Current technology	17.6	68.4	2.3
- New above ground technology	25.7		4.4
- New below ground technology	21.6		3.6
Option 3: Centralised storage			
- Casks/vaults in storage buildings	15.7		3.1
- Surface modular vaults	20.0	47.0	3.8
- Casks/vaults in shallow trenches	18.7		3.6
- Casks in rock caverns	17.1	40.6	3.4
Option 4: Adaptive phased management			
- With shallow underground storage	24.4	24.4	6.1
- Without shallow underground storage	22.6	22.6	5.1

BC$ = billion dollars Canadian.

The estimated costs for fuel cycles based on reprocessing and those based on long-term spent fuel storage followed by direct disposal were compared by the OECD/NEA in 1994 [26]. A more recent NEA study on existing and advanced fuel cycles [35] concluded that, over the whole fuel cycle including disposal costs, the relative fuel cycle cost of reprocessing might be from 20% less to 60% more than the cost of direct disposal, depending on the fuel cycle option. Given that fuel cycle costs were only in the range of 10-20% of the overall generation costs of nuclear electricity, the difference had a relatively minor impact.

5.3.3 Funding

In Chapter 2.3 the most important factors for the build-up and availability of funds were reviewed. A common way to build up the funds is to collect them as a fee per produced kWh. The availability of further resources or funds in support of HLW disposal programmes can therefore be characterised by the remaining operational lifetime of the existing power reactors. The build-up rate and the basis for calculating fees are reviewed regularly and might be influenced by technical as well as political factors. The build-up rate of the fund is also heavily influenced by political decisions on how the fund capital may be invested. The actual value of the funds collected will also depend heavily on the current economic environment dictating the rate of return on investments.

The capability of the reporting countries to build-up the necessary funds is not in question. The remaining operational lifetime of the existing reactor fleets is long enough to raise the funds covering all the costs of RWM and final waste disposal. The funding systems, as well as some financial details related to fundraising, are addressed in legislation and regulations. Generally, it is a government responsibility to check the adequacy and use of the funds and to make corrections if necessary.

For example, in Belgium, the costs of the management of radioactive waste are evaluated at cost price. To manage uncertainties in RWM, ONDRAF/NIRAS uses the methodology defined by the Electric Power Research Institute (EPRI). An insolvency fund helps in a situation of insolvency of a waste producer. Bilateral contracts defining in detail the financial mechanisms for each waste type, quantities and operations to be performed, have a validity period of 8 years after which they are renewed on the basis of the then perceived situation. Tariffs are based on the “fixed costs”, independent (within certain limits) of the quantities emplaced, and "variable costs", proportional to the quantities expected to be emplaced in the future. Producers make a binding minimum commitment to cover their share, regardless of the future fluctuations of their programme. These commitments take the form of an irrevocable contractual guarantee in the name of the producer. The guarantee covers the fixed part of the tariff. The fixed costs are charged to the producers according to the committed volumes. Variable costs are charged according to the volumes actually delivered and accepted. In the case of storage and disposal payments, the producers receive in return "reservations of capacity". Tariffs and guarantees escalate each year, beyond inflation, by a constant risk-free interest rate of 2%.

The long-term fund is interest bearing and invested in governmental bonds. The nuclear waste management fund is financed by the waste producers, but managed by ONDRAF/NIRAS under the supervision of an auditing committee made up of representatives of the Belgian state and of the main waste producers.

In the Czech Republic, the requirement to raise funds is enforced legally as well as being guaranteed by the "Act on the Peaceful Uses of Nuclear Energy and Ionising Radiation" (the Atomic Act) adopted in 1997. The build-up of the Czech RWM fund, from which the activities of the Radioactive Waste Management Authority (RAWRA) is financed, is done on an interest-bearing nuclear account opened with the Czech National Bank. The Ministry of Finance manages the nuclear account, which is included in the accounts of state financial assets and liabilities. However, the utilisation of the funds is decided by the government.

In the Republic of Korea, the Electricity Business Act defines a slightly different approach for different radioactive waste generators. Nuclear power plant operators should continuously update the cost of disposal for the HLW generated in their facilities and the corresponding fee. Non-power generators should only pay for their radioactive waste when they deliver the waste to the Nuclear Waste Management Business Operator. In this regard, non-power generators are only recommended to accumulate funds for disposal.

In general for the reporting countries, utilities generating electricity and other radioactive waste producers are responsible for and have been accumulating funds for the disposal of HLW, and the sums involved are considerable. In Canada, as of December 2006 deposits totalled 990 million CAN, and contributions continue to be made by all four waste generators. In Germany, owners of radioactive wastes – the utilities – have collected financial resources through their annual payments for the Konrad project totalling 850 million EUR and for the Gorleben project totalling 1.3 billion EUR. In the Czech Republic, the nuclear waste management fund is managed by the Ministry of Finance. Up to 31 December 2003 the accumulated fund for decommissioning is 4.3 billion CZK (about 150 million EUR), for interim storage 103 million CZK (3.5 million EUR) and 1.3 billion CZK (about 45 million EUR) for final disposal of HLW and SNF [18].

5.4 Stakeholder involvement

Decision makers might think that a technically sound basis for a HLW disposal concept may lead directly to success in public acceptance as well. However, experience shows that the scientific and engineering aspects of waste disposal safety are no longer of exclusive importance. Stakeholder involvement issues have become more and more important and this is also reflected in many countries in the legislative framework on HLW management. For HLW disposal projects (as indeed for most contentious projects in modern society), the traditional "decide, announce and defend" decision making has shifted to "engage, interact and co-operate" processes.

Consideration is increasingly being given to concepts such as “stepwise decision making” and “adaptive staging” that may help to accommodate the societal and political dimensions of HLW disposal. The key feature of these concepts is a plan in which development is done in steps or stages which are reversible, within the limits of practicability [7]. A shared view of experts dealing with HLW management is that public confidence can only be built through proactive, consistent communications and opportunities for dialogue. Societal research should preferably be an integral part of a decision-making process for siting a HLW disposal facility.

5.4.1 Public opinion and the state of knowledge

In most cases the country reports clearly demonstrate the need for further improvement of public confidence. There is a clear need for better communication of information in order to improve the level of public confidence in disposal proposals. There is ample evidence from the Eurobarometer work that the public is poorly informed as to both the issues with respect to HLW and to the advantages that nuclear energy can offer (cf. Chapter 3). For example, the public has misconceptions with respect to the volumes of HLW arisings and the current disposal practices. While there is now greater recognition that nuclear energy has benefits in terms of reduction in greenhouse gas releases and in diversity and security of energy supply, there is still a significant fraction (around 40%) which does not recognise these advantages. Concern about radioactive waste disposal appears to be a strong factor in the European public’s reluctance to support nuclear energy as part of the overall energy mix.

Many countries are finding strong resistance to radioactive waste disposal. For example, In Booan County, Korea, an unofficial public poll conducted in 2004 showed that around 90% of local residents opposed a radioactive waste disposal facility.[5] In Germany, at a local level very few people want a repository in their own region (80.6% against, 3.6% in favour). But the German public also considers waste disposal an urgent problem that needs to be solved (53% very urgent, 22.7% urgent, 5% not urgent).[6]

It is becoming widely accepted by the radioactive waste management community that a transparent, clear and permanent consultation process with the public is a prerequisite for any successful programme on waste disposal. It follows that transparent public consultation can be a major influence the timing of HLW disposal.

5.4.2 National commitment to stakeholder engagement

It now seems to be true in general that societal acceptance is a precondition for construction and operation of hazardous facilities, whatever they are. The process of site selection for HLW disposal is an example of such a societal choice, as a waste disposal site is perceived as a hazardous facility.

As has been mentioned before, commitment to public discussion is laid down in legal documents e.g. laws, government decrees, etc. Many national policies stipulate that radioactive wastes and the site selection process for radioactive waste repositories shall be managed transparently, openly, and that

5. http://wwwsoc.nii.ac.jp/aesj/division/sed/pbnc2004/pbnc2004.3-2.pdf.

6. Arbeitskreis Auswahlverfahren Endlagerstandorte (AkEnd): Site Selection Procedure for Repository Sites. Recommendations of the AkEnd – Committee on a Site Selection Procedure for Repository Sites, Köln, December 2002.

the government shall explain to the public during the site selection process its means for ensuring the safety of the facilities.

During the last decade governments have recognised the importance of formal and informal public engagement. Public hearings organised in the framework of environmental impact studies provide a form of formal public engagement, while different forums and site visits for local mayors might be forms for informal engagement.

In France public debates are organised by a special committee under the French Parliament, the National Commission on Public Debate. In the national debate on radioactive waste management the Ministry for Industry demonstrated its commitment to a public debate. The statistics on the consultation process and its supporting activities (600 000 information sheets, 16 000 case reports, 54 000 visits to the technical museum, 13 meetings lasting in total 60 hours, 3 000 attendees in 11 cities, 500 questions answered, meeting announcements in the French media, 15 000 website visitors, 370 media items) all demonstrate the commitment of the government towards public discussion.

France reports a high demand for information and dialogue, as well as input from multidisciplinary expertise. The Ministry for Industry points out that the conclusions of the debate were taken into account in the preparation of the draft law. The NWMO in Canada has declared that it intends to seek an informed, willing host community. In the Republic of Korea, for example, the government has decided that site selection shall be done by a local referendum, providing a high level of public participation in decision making. NUMO in Japan introduced an open solicitation involving all municipalities in the country to consider HLW disposal, having decided to adopt such an approach to find volunteer municipalities for preliminary investigation areas. The official announcement was made in 2002.

It is quite clear that a national commitment to public discussion is one of the most relevant factors in the timing of HLW disposal. The time taken to prepare for this, to conduct it and to respond to the results must all be taken into account in the development of any programme timetable.

5.4.3 Engaging the public in the debate

There are different mechanisms through which a “deficit” in public knowledge and confidence towards nuclear issues can be mitigated in the public consultation process. The Forum on Stakeholder Confidence, initiated by the NEA Radioactive Waste Management Committee, provides a forum for experience exchange between different expert groups. The success of a particular project very much depends on how the local and regional decision-making culture is taken into account [9].

An earlier Eurobarometer survey conducted in 2002 with the involvement of 16 000 people across the European Union concluded that the most trusted sources of information are independent scientists (32%), non-governmental organisations (31%), government bodies (29%), waste agencies (27%), mass media (23%) and international organisations (22%). Only 10% of Europeans trust information from the nuclear industry.

In France, the public confidence “deficit” in authorities and in scientists was encountered on several occasions in the public debate held in preparation for a new draft law on the future French HLW disposal strategy. Comments referred to the lack of information, the confusion between the respective roles of the actors and their involvement, as well as the need for an independent authority. Some participants expressed their doubts about the statements made by scientists. The following items were requested by the French general public: a) that the new law should address all radioactive waste and recoverable materials; b) to advance the HLW programme without taking shortcuts; c) to have independent assessment of the programme; and d) to have the possibility to stop the HLW programme, if need be. The French 2006 Planning Act on radioactive waste management takes account of these points.

In the Czech Republic, the objective of the “Radioactive Waste Management Concept” is to determine: strategically justified, scientifically, technically, environmentally, financially and socially acceptable principles.[7] Public surveys and discussion with selected stakeholders within the EC project RISCOM II, that was performed in 2000-2003, demonstrated that, in the Czech Republic, public knowledge about radioactive waste issues was poor. However, there is strong interest among the public to get more information related to nuclear issues.

Some years ago RAWRA started an information campaign directed at the general public. Information centres were constructed at RAWRA headquarters and at some candidate sites. A large number of meetings were held at individual sites and television broadcasts were also widely used in the campaign. To extend the level of knowledge of important decision makers, RAWRA regularly organises site visits for representatives of local authorities to Gorleben in Germany and Äspö in Sweden.

At a national level, the majority of the Czech population supports nuclear energy. However, at local and regional level the predominant part of the population disagrees with the proposal for a deep geological repository in their region. Generally, it is necessary to improve public knowledge (on all levels) concerning radioactivity, radioactive waste management and disposal, safety etc. The site characterisation programme has been suspended for 5 years because of public resistance. The most important factor in decision making in the Czech Republic currently is local public involvement. The main aim at present is to keep the general public informed about the radioactive waste management policy and its fulfilment. The RISCOM II study showed that the national policy should be more transparent.

In Japan, NUMO is responsible for public communication and has initiated a public communication programme on the current site selection stage [37]. The results of public interviews show that attitudes toward issues on HLW disposal are different before and after interviews. The pre- and post-interview questionnaire surveys highlighted the fact that, after learning about the role, advantages and risks associated with deep geological disposal, the interviewees who were initially against or took no position on the construction of a repository later replied that constructing a repository was obviously necessary.

Information on the risks associated with geological disposal and the associated technical explanations cannot generally be easily understood by non-experts. However, the results of the interviews suggest that even such complex information can be understood better as a result of introductory lectures and discussions. NUMO’s conclusion is that public participation in the decision-making process would improve public acceptance.

Five important factors were identified by NUMO for public communication.

- Most people in Japan have no concrete image of what HLW actually is.

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7. http://www.proe.cz/surao2/index.php?c=355&h=Radioactive%20waste%20management%20concept.

- Many people would like to know how issues associated with HLW disposal were perceived socially at the beginning of development of the nuclear power programme.
- Instead of being concerned about long-term safety, people tend to worry more about risks in the immediate future, such as operation of reprocessing plants and transportation of HLW.
- Some people expect major future developments in science and technology, so they do not recognize geological disposal as being a "favourable" strategy at present.
- The NIMBY syndrome (with some exceptions) clearly exists in the case of the HLW repository siting.

The Japanese view is that public debate at community level requires the following three elements [37]:

- opportunities for community residents to learn about the HLW disposal project and its implications from various perspectives;
- sufficient time for them to understand the necessity of the project and pertinent safety measures; and
- opportunities for public meetings where individuals can exchange their views.

A three-stage approach to site selection was considered to allow people sufficient time to debate the possibility of being a host community for the repository.

In Canada public communication addresses social, economic and cultural effects. In the Canadian programme special attention is paid to aboriginal communities that may be affected. In particular, it is stated that the NWMO will respect aboriginal rights, treaties and land claims.

In general, questions regarding transportation of radioactive waste are often high on the agenda. Although the added risks of high-level radioactive waste transportation are low they are a matter of concern to the communities and general public along the transportation route(s). Improvement and demonstration of transport safety, preparation of an emergency plan, and addition of some reserve routes and modes of transport might result from the process of public consultations. This might slightly influence the costs of the preferred waste management concept but has a relatively minor effect on the overall possibility for implementing HLW disposal facilities and their timing.

5.4.4 Involvement of local and regional decision makers

It is important to distinguish overall societal acceptance from acceptability to the local communities. The latter is a very important factor for the timing of a HLW programme since it is the local communities that must bear the actual or perceived negative consequences of the development [1]. It has therefore been recognised that in some countries the role of local administrations must still be clearly defined, and the involvement of local representatives in the decisions, debates and activities is essential to develop mutual understanding and political backing for a nuclear facility.

Based on the lessons learned during the French public debate, the 2006 Planning Act reshaped nuclear information systems through the creation of the High Committee for Transparency and Information on Nuclear Safety, the task of which is to help inform the public about nuclear activities and issue opinions on reforms intended to improve nuclear safety and radiation protection. The Act re-established the Local Information and Oversight Committees (*Comité local d'information et de suivi*) by confirming and clarifying their role and the financial support mechanisms required. In addition, it defined the responsibility of the Public Interest Group (*Groupement d'intérêt public*) for resource allocation, economic development and prioritisation in the territories in the proximity area.

In Belgium, ONDRAF/NIRAS, with the support of the Belgian government, decided to open a constructive and participative dialogue with the population of the communities hosting existing nuclear facilities. Partnership meetings were organised with a view to defining the disposal project, how the project can best be integrated in the life of the community and which conditions need to be fulfilled for the implementation of the project. The outcome of that partnership proved to be quite satisfactory for all the stakeholders as it lead to the candidature of two neighbouring communities.

In Sweden, the Oskarshamn community is one of the two communities chosen for further technical investigations in the site selection process for a high-level waste final repository. The successful basis for work with the municipality is the so-called "Oskarshamn Model",[8] which includes seven points:

1. Openness and participation: everything should be put "on the table" and there should be a real opportunity for influence by the municipality citizens.
2. The use of the Environmental Impact Assessment process as a tool: this should constitute a joint basis for a decision by all parties (the industry, the authorities, the county, and the municipality with its citizens).
3. The community council is a reference group: the competent elected officials are responsible to and on behalf of the voters. Public participation takes place within the framework of representative democracy.
4. The public is a resource: concrete plans and clear study results are a pre-requisite for public engagement and influence. Sufficient time must be given to the process. The "public" is the real expert on many relevant issues.
5. The environmental groups are also a resource: their members and experts can make valuable contributions. They have views that can help "stretch" the industry.
6. "Stretching" the implementer (SKB) to provide clear answers: "We build competence so we can ask the difficult questions – we ask until we get clear answers".
7. The competent authorities are the public's experts: The authorities must be visible throughout the process. The municipality decision on siting must come after statements by the competent authorities.

5.5 Impact expectations – Expert Group outcome

Following the detailed discussions by the expert group on both the factors influencing the choice of timing for HLW repository and those that impact on the reality of delivery, the initial view presented in Table 2.1 was revisited. The outcome view is shown here in Table 5.5 and is discussed in Chapter 6.

8. See NEA webpage: http://www.oecdnea.org/html/rwm/reports/2000/nea2829.pdf

Table 5.5 Summary of impact expectations of the Expert Group and final results after reviewing country reports and the 2005 Special Eurobarometer Report [4]

	Impact expectations	
Factors	Initial judgement of the Expert Group	Importance experienced
Technical		
Prospective HLW arisings	High	High
Heat production and interim storage	High	High
Suitable host rocks	High	High
Number of suitable candidate sites	Medium	Medium
Transportation of HLW	Low	High
Regulatory standards	Medium	Medium
R&D on the disposal system and its design	Medium	Medium
Applied R&D	Medium	Medium
R&D on new and/or innovative technologies	Medium	High
International collaboration and experience	Medium	Medium
Availability of national expertise	Medium	Medium
Social and political factors		
Importance of the nuclear programme	Medium	Medium
Legal framework	High	High
Continuity and stability of the decision-making process	High	High
Waste ownership and responsibilities	Low	Low
International constraints	Medium	Medium
Security	Low/High	High
Economic factors		
Ethics	High	High
Cost estimates and national practices	High	High
Funding	High	High
Stakeholder involvement	High	High

Chapter 6

DISCUSSION

In the previous chapter, the initial thoughts of the expert group were compared to the evaluation at the end of this project, following sharing of the country experience and consideration of public opinion, in as much as this can be judged for OECD countries via the work of the Eurobarometre (Table 5.5). [As discussed earlier, while this latter covers only the attitudes of the Euro 25, as it was at the time, it is one of the most extensive surveys of its kind and has the great merit of asking consistent questions across a range of nations. The issues associated with HLW disposal seem common across continents. Given this and limited other evidence, it is probable that the issues in the public mind are also similar.]

Table 5.5 shows that the initial views of the country experts nominated as members of this project were different in only three areas at the end. Firstly, the public view is that the currently proposed deep geological disposal approach is not convincing. This places greater emphasis in the medium and longer term on R&D for new and innovative technologies. Secondly, security is now ranked more highly due to events on the international scene. Thirdly, the public puts considerably more emphasis on security and radioactive waste transport issues than the EG believed should be the case.

The factors identified in this study as having an impact on the timing of HLW disposal are shown in Table 2.1. As can be seen, these are extremely diverse. Practical experience has shown that, while national policy might initially decide on the desirability of a particular timing for the availability of a HLW disposal site, a number of these factors intervene and inject significant delays; events take a course of their own.

Nevertheless, it is instructive to consider how decisions on the timing for the desired HLW repository availability can be made. Of the factors considered in Table 2.1, a number affect the choice of timing and others only the practical outcome. Even those that affect the choice of timing are still very diverse. Decision-making processes allowing consideration of such diverse inputs are available and have been used in a number of fields [e.g. 38 and 39].

This multi-criteria decision analysis (MCDA) technique can be used as an evaluation tool to make explicit how such decisions are achieved and what weight the various factors have had in the outcome. Importantly, stakeholders with different perspectives can be engaged in the process and sensitivity analysis is possible, illuminating the effect of the different weightings that result from different perspectives. While this study has shown that such decision aids have been occasionally used in the process of site selection, it would appear that they have not been used to decide on an appropriate timing. (Appendix 5)

An essential feature of such an approach is to ensure that the "impact parameters" considered cover all the key features of the decision without undue overlap. Figure 6.1 shows a possible set of such timing impact parameters, distilled from Table 5.5 and presented under the four branches of technical factors, socio/political factors, economic factors and stakeholder factors. It should be emphasised that this is purely for the purposes of illustration. Any practical application of the technique requires input from and preferably consensus from the stakeholder groups involved.

Returning to the overall position and considering the high level issues, all stakeholder groups seem to agree that the principle of intergenerational equity requires early disposal of HLW. There is broad agreement amongst the experts that deep geological disposal is an entirely appropriate response, but the public remains unconvinced. Whilst the resulting impasse is resolved, storage can provide a safe interim solution, but this is not sustainable in the long term. Opponents of nuclear power argue that while the HLW disposal issue remains unresolved a further expansion should not be permitted; this may lead them towards resisting resolution, even if the case for deep geological disposal is entirely adequate. However, disposal of existing HLW will be necessary with or without any future nuclear power generation.

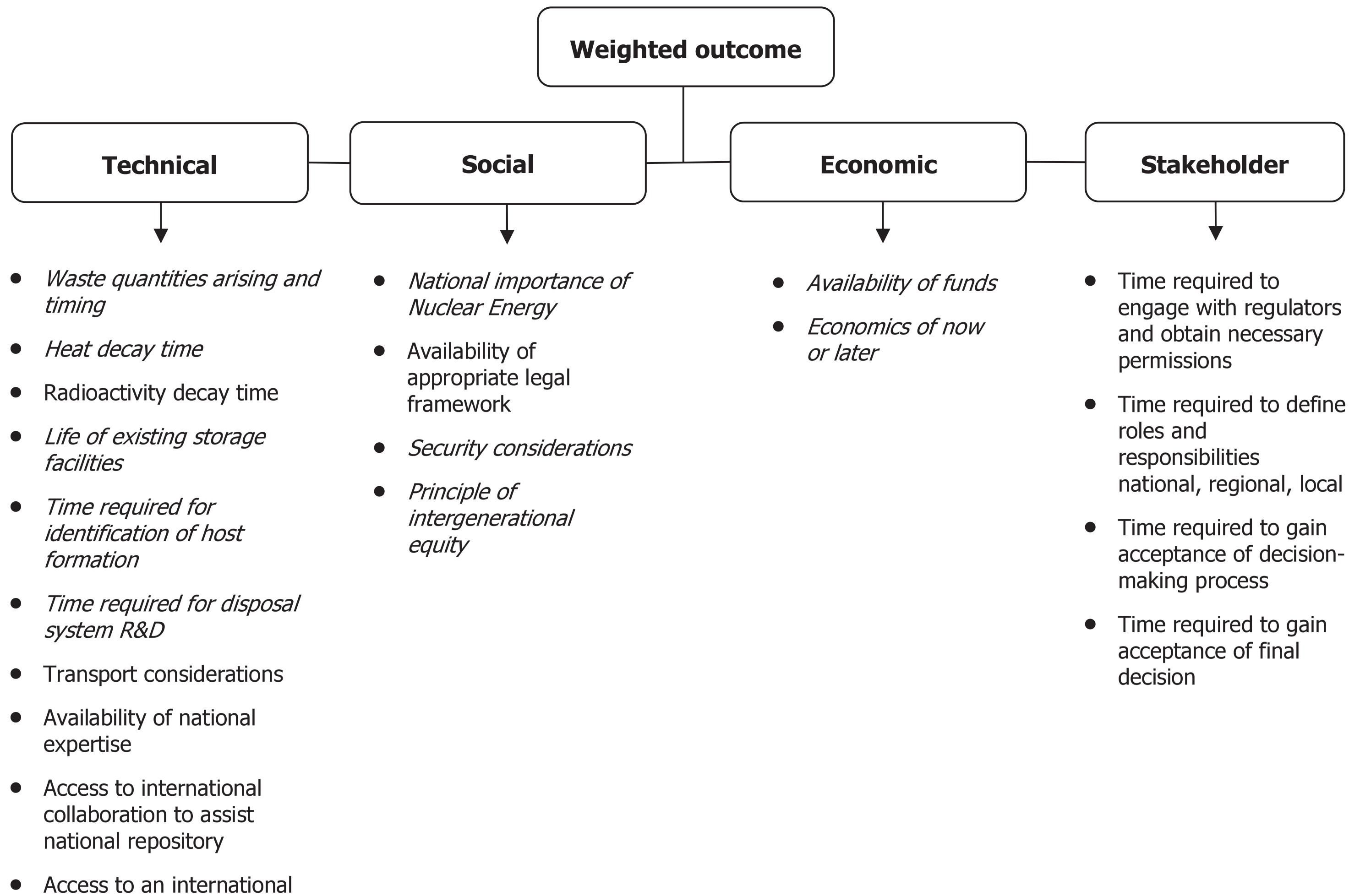
Moving on to summarise the implementation aspects, most countries have well developed waste management programmes. Acceptable geological formations are generally not an issue. However experience has shown that the time schedules originally envisaged prove to be ambitious. This is driven by the twin factors of the detail needed to prove the acceptability of a chosen site and the time taken to gain public and political acceptability.

Governments have a role to play in providing clear commitment and support towards the national programme. Given the durations involved, this needs to continue through successive governments. Their further role is to ensure the clarity of the legislation and the clarity of the roles of the actors in the decision making process at local, regional and national levels, together with the transparency of the decision-making process.

Clearly the availability of adequate funding and the skilled resources necessary throughout the length of the programme are also essential ingredients, and international cooperation can be of assistance by avoiding duplication of work and sharing of experience.

Finally, the developing technologies of partitioning and transmutation may have a role to play in the future, in eliminating some of the long lived radionuclides that seem to be of particular concern in the public mind. These technologies may also reduce the need for further repositories if they can be commercially deployed. However, deep geological disposal will still be needed, even in the event of successful commercial deployment.

Figure 6.1 Possible set of such timing impact parameters



Note: Items in italics denote those that are primary strategic drivers affecting the decision on timing.

Chapter 7

CONCLUSIONS

Regardless of future R&D and technological developments and of whether national policies are to phase out or continue with nuclear power, repositories for the disposal of HLW will be needed to deal with existing wastes. As demand for nuclear power appears to be expanding globally, even further efforts are needed to implement HLW disposal in a timely manner, up to and including final disposal. A key challenge for the nuclear industry is timely implementation of final disposal by providing the site-specific safety assessment that shows that HLW can be safely disposed of, and at the same time achieving the necessary public acceptance through participation in an open and transparent decision-making process. It is clear from the Eurobarometer 2005 and its 2006 update data that public concern with respect to radioactive waste disposal is a key factor in reducing public support for nuclear energy in general (cf. Chapter 3). One of the major factors dictating the long timescales for achieving final repositories is a failure to further improve public trust and confidence, and involve the public in the selection of the proposed solutions.

If governments wish nuclear energy to be part of their energy mix, their publics need to be much better informed with respect to the issues surrounding radioactive waste management and disposal. In 1995, the NEA published a joint collective opinion [33] in which it concluded that deep geological disposal is a feasible option for HLW. The evidence from the Eurobarometer data is that the majority of the public still do not share the opinion of the technical experts (cf. Figure 3.6). Further, a significant fraction of the public believes that radioactive wastes are produced in similar quantities to other toxic wastes, that radioactive waste is sent to other countries for disposal or dumped at sea, that radioactive waste transport, even of LLW, presents a significant public risk and that there is currently no safe means by which such wastes can be disposed of. As long as a significant fraction of the public continues to hold such misconceptions, public opinion will continue to cause delays in HLW disposal programmes.

More positively, the data also show that the populations in countries with nuclear power currently in their energy mix are better informed on these issues, that the vast majority in all countries would like to see a solution progressed as soon as possible, and that most people recognize the potential political unpopularity of trying to make such progress. Importantly, most people would want to be engaged in any process which might lead to a repository in their locality.

This study began with the judgments of the national experts on what issues are of most importance and re-examined these in the light of the country reports and the available evidence on public attitudes. There are many factors influencing the timing (in either direction) of a HLW disposal system. The original judgment of the Expert Group regarding the importance of these factors, and the final result based on the review of actual country experiences and public views presented in the *Special Eurobarometer 227 – Report "Radioactive waste"* study [4], are presented in the Table 5.5.

The detailed analysis in Chapter 5 has largely confirmed the initial views of the technical experts as set out in Chapter 2. It is clear that the messages from the work of the RWMC and other analysts, illuminating the importance of stakeholder issues at all levels, has been understood and absorbed by the community of waste management experts. No longer are the technical issues regarded as the dominating factors. The differences between the experts' initial views and the public's view, as extracted from the Eurobarometer data, still differ in three significant areas. A majority of the public, in both countries with and without nuclear power, believe that there is currently no safe solution for radioactive waste disposal. This indicates that confidence in scientists and experts still has to be built and that further efforts in communication are required. It may also indicate that the public has high expectations from innovative techniques yet to be invented or developed. Similarly the public places considerably more emphasis on security and radioactive waste transport issues than the EG believed should be the case.

The development of the technical and scientific case for a repository is obviously the other key area that demands a significant timescale. The safety case for a HLW repository is of the utmost importance and the needed research efforts are extensive and time consuming. Further, in an open society the final selection of a disposal concept and of a site will be challenged by stakeholders from every possible angle. Strong arguments must be available to show that the optimal overall choice has been made from a safety point of view as well as from the technical, economic and social viewpoints. Extensive scientific and technical background material will give a solid basis for the arguments in this discussion. The trend is that the public dialogue and the decision-making process are becoming increasingly important and the time needed should not be underestimated.

The conclusions from this study are:

Overarching issues

- It seems to be a generally agreed principle amongst the industry, the public and politicians that each generation that benefits from nuclear power should honour its responsibilities and should deal with its radioactive waste in a manner that protects human health and the environment, now and in the future, without imposing undue burdens on future generations. This ethical principle of "intergenerational equity" is a driver to avoid undue postponement of HLW disposal.
- There is a broad agreement among experts that deep geological disposal is technically feasible and constitutes a safe option for the relatively small volumes of HLW compared to other toxic waste types.
- Interim storage is needed in any case to allow the levels of radioactivity and heat output to decay before the next step or process of the waste management strategy can be enacted. Long-lived waste and spent fuel have been safely and securely stored in OECD member countries for several decades. Such interim storage could continue for many more decades, provided that proper controls and supervision continue. However, this can only be an interim solution; at some point a final disposal solution must be implemented.
- The general political climate regarding nuclear issues, and political stability and continuity of decisions already made on principles and time schedules, will influence the views of the general public and its confidence in the decision-making process and thereby the timing of the implementation of HLW disposal.
- There is clear evidence that significant fractions of the public still have serious misconceptions with respect to the issues surrounding nuclear waste. The nuclear industry, together with governments in those countries who would like a component of nuclear power in their energy mix, has a responsibility for and a significant challenge in presenting its case to the public. A number of OECD governments (e.g. Canada, France, Germany, Japan, Korea, United Kingdom), are undertaking public consultation exercises as part a wider process of establishing a consensus. The way in which Finland sought and obtained public support for its programme is widely regarded as a model for future timely progress.

- Opponents to nuclear energy often claim that further expansion of nuclear power would drastically increase the radioactive waste problem. Since the generated volumes are small and a timely implementation of HLW repositories will still be needed for already produced quantities of HLW, irrespective of any future expansion of nuclear power, this argumentation is spurious.
- Currently, terrorist and proliferation risks are high on the political agenda and may act as new drivers in the implementation of HLW disposal systems. A number of governments are supporting R&D on novel approaches to management of HLW which potentially mitigate disposal issues, such as partitioning and transmutation (P&T) which offers the possibility of significantly reducing the amount of long-lived radionuclides in HLW.

Issues important for timing of HLW disposal

- Most countries already have well developed waste management programmes with time schedules for disposal implementation. However, experience has shown that, in practice, the time schedules originally envisaged prove to be ambitious. This is driven by the twin factors of the scientific detail needed to prove the choice and the technical acceptability of a chosen site, and the time taken to gain public and political acceptability of the outcome choices.
- The availability of suitable host geological formations and the number of potential sites are generally good in most countries and are not limiting factors for timing from a technical view point. Technically matured disposal systems, comprising sites, civil works and waste packages, each contributing to the functions required to ensure short and long term safety, are developed in several countries and are generally not a limiting timing factor. However, the societal and political acceptance of these systems is currently the limiting factor for implementation in most countries.
- The clear commitment and support of successive governments towards a national radioactive waste management programme will help its timely implementation and is an important factor in reaching a publicly acceptable disposal solution.
- Clear legislation and well-defined roles of the actors in the decision-making process at the local, regional and national levels are key factors in a successful and timely HLW disposal programme.
- The structure and transparency of the decision-making process and the level of and possibility for public participation are key issues for achieving public acceptance. Much progress has been made in developing stakeholder dialogue and transparent public consultation. This work is time consuming and has a large impact on the timing of HLW disposal.
- The level and availability of funds is an important factor which can influence the timing of HLW disposal. All countries considered have arrangements for collecting the appropriate funding from the waste producers to ensure this does not become a limitation.
- The availability of skilled staff should be planned over the implementation period to avoid unnecessary interruptions in what has become a very lengthy process in many countries.
- International cooperation can shorten the time needed in the implementation process by avoiding duplication of research and sharing lessons on stakeholder engagement.
- R&D on new technologies has the promise of significantly reducing the quantities of long-lived radioactive waste resulting in reduced volumes for disposal in a repository. It also holds appeal to people who are unconvinced by current proposals for deep geological disposal and are especially concerned about the long lived isotopes. This may be a driver for delay in progressing with a repository. R&D into partitioning and transmutation is not

simply a response to public concern. It is part of a responsible and ethical approach towards good resource management, i.e. sorting, recovery, recycling and therefore resource saving. However these technologies need significant development and time before they are deployable at a commercial scale. Geological disposal of currently vitrified waste and of fission product wastes are still be needed, even in the event of successful commercial employment of partitioning and transmutation technologies.

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Appendix 1

GLOSSARY

AkEnd	Arbeitskreis Auswahlverfahren Endlagerstandorte – Committee on a Site Selection Procedure for Repository Sites (Germany)
APM	Adaptive phased management
ASN	*Autorité de sûreté nucléaire* (France)
BANANA	Build absolutely nothing anywhere near anyone
CANDU	Canadian Deuterium Uranium (type reactor)
CASTOR	CAsk for storage and transport of radioactive material
CEA	*Commissariat à l'énergie atomique*
CNE	*Commission nationale d'évaluation* (France)
CRIEPI	Central Research Institute of Electric Power Industry (Japan)
CS	Centralised storage
DGD	Deep geological disposal
EC	European Commission
EDZ	Excavation disturbed zone
EIS	Environmental Impact Study
EPRI	Electric Power Research Institute (United States)
EU	European Union
FP	Framework Programme (EC)
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit (Germany)
HABOG	A HLW/SF vault storage site (Netherlands)
HADES	High Activity Disposal Experimental Site (Belgium)
HLW	High-level waste
HM	Heavy metal
IAEA	International Atomic Energy Agency
IGSC	Integration Group for the Safety Case
ILW	Intermediate-level waste
ITC	International Training Centre (Switzerland)
JAEA	Japan Atomic Energy Agency
JNC	Nuclear Cycle Development Institute (Japan)
LLW	Low-level waste
MOX	Mixed oxide fuel
MTU	Metric tons of uranium
NAGRA	National Co-operative for the Disposal of Radioactive Waste (Switzerland)
NDC	The Committee for Technical and Economic Studies on Nuclear Energy and the Fuel Cycle
NEA	Nuclear Energy Agency
NIMBY	Not in my back yard
NPP	Nuclear power plant
NUMO	Nuclear Waste Management Organization (Japan)
NWMO	Nuclear Waste Management Organization (Canada)
OECD	Organisation for Economic Co-operation and Development

ONDRAF/ NIRAS	*L'Organisme national des déchets radioactifs et des matières fissiles enrichies/ Nationale Instelling Voor Radioactief Afval En Verrijkte Splijtstoffen* (Belgium)
P&T	Partitioning and transmutation
PRACLAY	Preliminary demonstration test for CLAY disposal of highly radioactive waste (Belgium)
PWR	Pressurised water reactors
R&D	Research and development
RAWRA	Radioactive Waste Repository Authority (Czech Republic)
RISCOM	risk communication program for consulting and individual assessment on contaminated sites (Risikokommunikationsprogramm zur Beratung und Einzelfall-prüfung auf kontaminierten Standorten)
RWM	Radioactive waste management
RWMC	Radioactive Waste Management Committee
SAFIR	Safety Assessment and Feasibility Interim Report
SCK•CEN	Studiecentrum voor Kernenergie – *Centre d'étude de l'énergie nucléaire* (Belgium)
SFC	Safety and feasibility case
SKB	Svensk Kärnbränslehantering AB (Sweden)
SNF	Spent nuclear fuel
SNS	Storage at nuclear reactor sites
STRIPA	Nuclear waste disposal programs in Sweden
VLLW	Very low-level waste
WAC	Waste acceptance criteria

Appendix 2

COUNTRY PROFILES[1]

Belgium

- 7 commercial reactors;
- fuel fabrication.

Electricity and gas market reforms have been implemented and improvement of cross border electricity exchanges progressed. Energy audits in enterprises and buildings as well as green certificate trading schemes are introduced to tackle climate change. Nuclear phase out between 2015-2025. Challenging issues for Belgium in the area of energy policy are:

- come to harmonised national energy policy goals between the federal and regional governments;
- cover future supply gap induced by the nuclear phase out by combination of energy savings, electricity imports and additional electricity generating capacity;
- coordinate the multi layer regulatory regime and the multi regulator structure;
- meet Kyoto targets for energy related CO_2 emissions.

Canada

- 22 commercial reactors;
- fuel fabrication, research reactors.

The Nuclear Fuel Waste Act (NFWA) entered into force in November 2002 and required nuclear utilities to establish the NWMO. Under the NFWA, the NWMO is responsible for implementing the government-approved approach, adaptive phased management, for the long-term management of nuclear fuel and nuclear waste. Additionally, the NFWA requires nuclear energy corporation to set aside, in trust, funds to cover the costs of managing nuclear fuel waste over the long-term. The Government is responsible for providing oversight of NWMO activities in accordance with the NFWA.

Challenging issues for Canada in the area of energy policy are:

- achieving broad public support is necessary to ensure the acceptability of a concept for managing nuclear fuel wastes; and
- defining the future role of nuclear energy in the country.

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1. In-depth Review *Chapter from Energy Policies of IEA Countries* – Japan/2003, Canada/2004, France/2004, Republic of Korea/2004, Belgium/2005, Germany/2002, Czech Republic/2005.

Czech Republic

- 6 commercial reactors;
- research reactors.

Strong economic growth since 1990, change of the energy sector. Decrease of energy intensity by 17% and decrease of the emissions from fuel combustion by 24% between 1990-2003. The Czech Republic is the second major electricity exporter in Europe.

Challenging issues for the Czech Republic in the area of energy policy are:

- market concentration versus competition for the gas and electricity markets;
- many different types of international energy connections;
- currently renewable energy does not play a major role – 2.5% for primary energy supply and 4.2% for electricity generation;
- coal is the most important energy source for the country, accounting for 47% of TPES in 2003;
- nuclear energy plays an important role in the electricity generation accounting for 33.8%.

France

- 59 commercial reactors;
- 1 fuel fabrication, 1 enrichment, 1 reprocessing facility;
- 2 major research reactors.

French energy policy over the past decades has been characterised by a centralised, nation-based approach, with strong government involvement. Consumers of all classes enjoy some of the cheapest energy prices in the OECD, security of supply for all energy sources is sound, and the country has one of the lowest levels of greenhouse gas emissions (GHG) per unit of GDP in the world.

Introduction of competition and growing internationalisation of the energy sector changes the environment in what the energy policy has to function.

Challenging issues in the French energy policy are as follows:

- liberalisation of electricity market;
- government's potential;
- involvement in influencing the magnitude and timing of additions to the generating portfolio;
- meet the ambitious near- and long-term goals in reducing CO_2 emissions;
- liberalisation of the gas sector;
- to ensure the capability to build, operate and maintain nuclear facilities is preserved in order to maintain the nuclear option;
- to maintain the tradition of contributing substantially to energy R&D.

Germany

- 17 commercial reactors;
- fuel manufacturing.

Gradual phase-out policy for the nuclear power plants until 2025. Germany has the largest electricity and the second largest gas market in Europe.

Challenging issues for Germany in the area of energy policy are:

- meet ambitious targets to reduce greenhouse gas emissions;
- maintain significant role of energy efficiency and conservation, co-generation and renewables (12.5% by 2010) and fossil fuels in Germany's energy strategy;
- maintain the significant coal-based electricity generation for a longer term.

Japan

- 55 commercial reactors;
- 3 reactors under construction;
- 1 reactor under decommissioning;
- enrichment, fuel manufacturing, reprocessing facilities and research reactors;
- 5 000 national or private facilities utilising various types of radiation.

Japan has partially liberalised electricity and gas markets. The country ratified the Kyoto Protocol and developed an enhanced policy package to achieve the Kyoto targets. Balancing the 3Es (energy security, economic efficiency, environment) is still a challenge.

Basic energy policy documents are:

- Long-term Energy Supply and Demand Outlook.
- New Guideline for Measures to Prevent Global Warming.

Challenging issues for Japan in the area of energy policy are:

- diversification of the energy mix from oil import dependence;
- promotion of nuclear power and renewables to meet goals of the country's climate change policy;
- sharpening summer peak demand for electricity;
- improving energy security which is more critical for Japan than in most OECD countries;
- maintain the central role of nuclear power in the Japanese energy policy both in terms of security of supply and climate change mitigation, and it's competitiveness;
- maintain or increase the current level of nuclear power generation (30% to 40% of the total electricity generation) even after 2030;
- increase public confidence in nuclear electricity production;

- ensure the role of nuclear power in liberalised electricity markets;
- relatively high energy prices in comparison with other OECD countries;
- completion of market liberalisation for gas and electricity markets;
- establishment of an independent national transmission system operator;
- improvement of the interconnections between different regions in Japan;
- improvement of economic efficiency.

Republic of Korea

- 20 commercial reactors;
- 4 reactors under construction;
- fuel manufacturing facilities and research reactors.

Decreasing economic growth for the last 3 years.

Main energy policy documents are:

- Vision and Development Strategies for Korea's Energy policy toward 2010;
- The Second National Energy Plan.

Challenging issues for the Republic of Korea in the area of energy policy are:

- strong dependency upon primary energy imports and strong influence on the world energy markets being the third largest importer of crude oil and second largest importer of liquefied natural gas;
- total energy demand annual increase is 7.5%, electricity demand growth rate is 4%;
- considerable growth of greenhouse gas emissions (annual average 5.1% from 1990 to 2002);
- improvement of the air quality in the metropolitan area;
- improvement of oil import security – being the country the main exporter of refined oil products in the region;
- improve oil exploration in its 17 oversees exploration projects in 11 countries;
- promote energy conservation;
- decrease of coal reserves inside the country;
- gas market reform, improvement of security of gas supply;
- to boost use of renewables up to 5% until 2011;
- to construct a dozen of NPPs until 2015;
- launch an electricity tariff reform.

Appendix 3

TECHNICAL DESCRIPTION OF THE FOUR MANAGEMENT APPROACHES STUDIED IN CANADA [6]

Option	
1. Deep geological disposal in the Canadian shield	A long-term management approach based on a central deep geological repository located in the Canadian Shield at a nominal depth of 500 to 1 000 metres below surface. Used fuel would be transported from existing interim storage facilities at nuclear reactor sites, to a central location. At the central facility, the used fuel would be transferred into corrosion-resistant containers that would be placed in rooms excavated deep in the rock over a period of about 30 years. There would be a need for transportation containers and facilities to produce them; processing facilities to load the fuel into transportation containers; production facilities for deep repository containers; processing facilities to transfer the fuel from transportation to deep repository containers; and production facilities for sealing materials. Once all of the used fuel is transferred to the deep repository, it would be monitored over time prior to final backfilling, sealing and closure of the facility. Following closure of the deep repository, maintenance, inspection and security-related operations would be minimal. Such a facility would be designed to be passively safe over the long-term and not rely on institutional controls to ensure safety. The current owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transported from the reactor sites to the central facility for long-term management.
2. Storage at nuclear reactor sites	Long-term storage at existing reactor sites would involve the expansion of existing dry storage facilities or the establishment of new, long-term dry storage facilities at each of the seven used fuel storage sites in Canada. In the latter case, used fuel would be transferred from the existing interim storage facilities to newly designed storage containers and storage buildings for long-term management. Storage would require an ongoing programme of regular replacement and refurbishing activities, as facilities would be renewed indefinitely. Processing buildings would also be required to load the fuel and provide for its on-site transfer. The storage facilities would require ongoing maintenance, inspections and security systems. The current owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transferred to the long-term storage facilities at the reactor sites.
3. Centralised storage	Centralised extended storage involves creating new, long-term storage facilities at a central location. Used fuel would be transferred from the seven interim storage sites in Canada to a newly designed facility. Conceptual designs have been developed for a central storage facility built above ground, or below ground. There would need to be transportation containers and facilities to produce them; processing facilities to load the fuel into transportation containers; production facilities for storage containers; and processing facilities to transfer the fuel from transportation to storage containers. Storage would require an ongoing programme of regular replacement and refurbishing activities, as facilities would be renewed and expanded indefinitely.

	Once all the used fuel is transferred to the long-term storage facilities, ongoing maintenance, inspections and security systems would be required. The current owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transported from the reactor sites to the central facility for long-term management.
4. Adaptive phased management	A staged management approach with three phases of implementation: • Phase 1: Preparing for central used fuel management • Phase 2: Central storage and technology demonstration • Phase 3: Long-term containment, isolation and monitoring **Phase 1** (approximately the first 30 years): Preparing for central used fuel management would comprise the following activities: • Maintain storage and monitoring of used fuel at nuclear reactor sites. • Develop with citizens an engagement programme for activities such as design of the process for choosing a site, development of technology and key decisions during implementation. • Continued engagement with regulatory authorities to ensure pre-licensing work would be suitable for the subsequent licensing processes. • Select a central site that has rock formations suitable for shallow underground storage, an underground characterisation facility and a deep geological repository. • Continue research into technology improvements for used fuel management. • Initiate the licensing process, which triggers the environmental assessment process under the Canadian Environmental Assessment Act. • Undertake site characterisation, safety analyses and an environmental assessment for the shallow underground storage facility, underground characterisation facility and deep geological repository at the central site, and to transport used fuel from the reactor sites. • Obtain a licence to prepare the site. • Develop and certify transportation containers and used fuel handling capabilities. • Obtain a licence to construct the underground characterisation facility at the central site. • Decide whether or not to proceed with construction of a shallow underground storage facility and to transport used fuel to the central site for storage. • If a decision is made to construct the shallow underground storage facility, obtain a construction licence and then an operating licence for the storage facility. **Phase 2** (approximately the next 30 years): Central storage and technology demonstration would comprise the following activities: • If a decision is made to construct shallow underground storage, begin transport of used fuel from the reactor sites to the central site for extended storage. • If a decision is made not to construct shallow underground storage, continue storage of used fuel at reactor sites until the deep repository is available at the central site. • Conduct research and testing at the underground characterisation facility to demonstrate and confirm the suitability of the site and the deep repository technology. • Engage citizens in the process of assessing the site, the technology and the timing for placement of used fuel in the deep repository. • Decide when to construct the deep repository at the central site for long-term containment and isolation. • Complete the final design and safety analyses to obtain the required operating licence for the deep repository and associated surface handling facilities. There may be a need for transportation containers and facilities to produce them; processing facilities to load the fuel into transportation containers; production facilities for storage containers; and processing facilities to transfer the fuel from transportation to storage containers. **Phase 3** (beyond approximately 60 years): Long-term containment, isolation and monitoring would comprise the following activities: • If used fuel is stored at a central shallow underground facility, retrieve and repackage used fuel into long-lived containers.

	• If used fuel is stored at reactor sites, transport used fuel to the central facility for repackaging. • Place the used fuel containers into the deep geological repository for final containment and isolation. • Decommission the shallow underground storage facility. • Continue monitoring and maintain access to the deep repository for an extended period of time to assess the performance of the repository system and to allow retrieval of used fuel, if required. • Engage citizens in on-going monitoring of the facility. • A future generation would decide when to decommission the underground characterisation facility and any remaining long-term experiments or demonstrations of technology, and when to close the repository, decommission the surface handling facilities and the nature of any post-closure monitoring of the system. There may be a need for production facilities for used fuel containers; processing facilities to transfer the fuel from storage to the deep repository; and production facilities for sealing materials. The current owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transported from the reactor sites to the central facility for long-term management.

Appendix 4

COUNTRY REPORTS

BELGIUM

Introduction

The purpose of this document is to present a reference planning of the decisions and actions estimated to be necessary for the progressive implementation of the geological disposal of all categories of MLW/HLW (long-lived waste) in Belgium. Such a planning is intended as a basis for the further definition of an overall decision-making framework to be eventually agreed upon between ONDRAF/NIRAS, the WMO in Belgium, and the other major institutional stakeholders (e.g. supervising authorities, the nuclear safety authorities, the environmental protection authorities, the main waste producers, other potentially involved authorities at regional or local level).

The proposed planning includes all the major implementation steps i.e. design, siting, licensing, construction and operation, sealing and final closure. It considers a stepwise disposal of the waste, starting with the waste that already exists and that does not require an on-surface cooling period, and ending with the heat-emitting waste which requires 60 years interim storage.

The described steps and planning have not yet been agreed upon between ONDRAF/NIRAS and the concerned stakeholders, regulators, or supervising authorities. The present document is thus to be considered as working material which in no case can commit ONDRAF/NIRAS.

Specific background

Quantities and categories of waste

The quantities and categories of waste expected to be disposed of in a deep geological repository in Belgium were estimated essentially in function of the following elements:

- "Phasing out" Law of 2003, according to which the 7 NPP units presently operated in Belgium should be retrieved from service after max. 40 years of operation, i.e. from 2015 to 2025.
- Ministerial decision of 1993 to put a moratorium on the conclusion of new reprocessing contracts, which means in practice that the spent fuel produced after the expiration of those contracts is being stored at the NPP sites. However, as far as final disposal is concerned, and in agreement with a ministerial decision of 1998, open and closed fuel cycles must be considered in parallel by ONDRAF/NIRAS.
- Existence of other sources of long-lived waste in particular research reactors, UOX and MOX fuel fabrication plants, pilot fuel reprocessing plant being dismantled, etc.

Depending on the period of production (time of availability) on one hand, and of the cooling time necessary before disposal on another hand, a distinction is made between the following 3 groups of waste:

- Group 1: historic waste

- Group 2: dismantling waste
- Group 3: heat-emitting waste

In function of this, Table 1 (full reprocessing scenario) and Table 2 (no further reprocessing scenario) give the envisaged quantities (in m^3) and expected times of availability for the different waste streams/groups.

Disposal host rock

No formal in principle decision has yet been taken to go to geological disposal as regards the national long-term management policy for HLW (vitrified waste from reprocessing or non reprocessed spent fuel) and MLW.

Therefore, no decision has yet been taken for a host formation and an implementation site.

However, as explained hereafter, the investigations for deep geological disposal in Belgium started more than 30 years ago, and have been up to now focused on argillaceous settings, and more particularly on the Boom Clay layer beneath the Mol/Dessel nuclear zone, NE Belgium). The Boom Clay is considered as the reference host formation.

It should also be noted that there is currently no specific regulations applicable to geological disposal. Such a regulation is being developed by the Belgian nuclear regulators.

Status of the R&D work

The Belgian R&D work on the geological disposal in clay of long-lived and/or high level radioactive waste was launched in 1974. In the early 1980s was constructed in the Boom Clay layer the HADES Underground Research Laboratory, which is still in operation, and which is nowadays focused on the PRACLAY in situ large-scale heater testing.

The latest Safety & Feasibility Interim Report (SAFIR 2) summarises the results of the investigations performed between 1990 and 2000. The SAFIR 2 Report was supplemented by a background report dealing with the societal aspect of sustainable management of radioactive waste. The SAFIR 2 report was subjected to an international Peer Review, organised by the NEA. The outcome of this review was published in January 2003. Overall, the NEA Peer Review concluded that: 1) safe and feasible disposal in Boom clay is achievable; and 2) the Belgian disposal programme is mature enough – from a scientific and technical point of view – to move progressively forward towards implementation. This requires:

- Carrying out additional R&D and demonstration activities to reduce remaining uncertainties.
- Obtaining specific policy and regulatory guidance.
- Considering societal issues and involving stakeholders in decision making.
- Tackling the siting issue.

General disposal strategy

The strategy pursued by ONDRAF/NIRAS is to **transfer any stream of MLW/HLW to the geological repository as soon as (reasonably) possible**, provided that the following conditions with respect to the repository are met:

- Adequate level of safety and protection for the environment.
- Technical feasibility at an industrial level (incl. economic aspects).
- Societal acceptance (of the repository design and the location of the site).
- Deliverance of required licences for repository construction, operation and closure.

Hence, based on the above, the general strategy will be to start to work towards construction and operation of a repository section as soon as a waste stream is available for geological disposal (i.e. post-conditioned if necessary), and as soon as the above-mentioned conditions are met. For general planning purposes, a simplification of the sequence of disposal of all categories MLW/HLW waste is required, since:

- There are more than ten different classes of category MLW/HLW and these are expected to become available at a wide spectrum of times.
- Some classes are represented by only a relatively small quantity of waste.
- To minimize operational safety hazards and disposal system disturbance (mainly the Boom Clay), it is required to limit the duration of the operational phase of a repository section (i.e. part of the repository that is dedicated to a specific group of waste).

Planned developments

Stepwise R&D

The purpose of the current R&D programme is to reduce/eliminate the remaining uncertainties, in order to be able to confirm the absence of scientific and technical obstacles for the reference solution (disposal in Boom Clay) by 2020.

Integrated set of arguments (safety and feasibility case) supporting confidence in safety, feasibility and scientific understanding will be produced around 2013 and in 2020.

The **PRACLAY** experimental work will run in parallel with the build-up of the SFCs and be a source of key information to these documents.

Societal dialogue

The purpose is to legitimate progressively the reference solution (i.e. disposal in Boom Clay) and provide participative ways forward towards siting and site acceptability. This will be made notably through a National Waste Plan which will focus on open issues in the full sequence of waste management as well as a kind of strategic environmental impact assessment (as per EC Directive 2001/42).

This effort should run in close interaction with the above-mentioned R&D programme. Iterative feedback between societal concerns and R&D orientations will a.o. be ensured during the preparation of the SFCs (e.g. by providing scientific and technical responses to specific concerns expressed by stakeholders).

Once site selection (a societal choice) and site characterisation made, one can enter a stepwise licensing phase.

In absence of specific regulations, it is considered in a hypothetical licensing sequence that a Preliminary Safety Assessment Report (PSAR) and an Environmental Impact Assessment (EIA) will be required to obtain site confirmation.

Stepwise implementation

As already justified above, the overall implementation of the repository (licensing, construction, operation, partial closure) will be carried out in several phases according to a stepwise approach, in order to:

1. increase confidence by learning from the experience gained during repository development, construction and operation;
2. allow for progressive licensing;
3. allow for progressive technical and economic optimisation;
4. benefit from the progress of scientific and technological knowledge in general.

Sequence of the necessary actions

The intention is to focus the disposal of MLW/HLW around a small number of groups of waste streams. For each disposal group, a dedicated repository section will be allocated. Therefore, dedicated design, licensing, construction, operation and closure work will be necessary for each repository section (or disposal group). Each section has to be outside the area of interactions with other sections as far as these interactions could negatively affect the safety of the repository as a whole. This grouping does not necessarily have to be made along the category MLW and category HLW division. The grouping will primarily be based on the time of availability and involved quantities of the different waste streams.

For each disposal group, the general sequence of planned activities will be:

1. development of a PSAR for the specific disposal group (note that the work on the PSAR of the first disposal group is considered to be part of the project phase);
2. approval of the PSAR;
3. construction of the repository section specific to the disposal group;
4. development of a SAR for the specific disposal group and approval by the end of the construction phase;
5. operational phase;
6. development of a SAR for the closure of the specific repository section and approval by the end of the operational phase;
7. sealing and closure of the repository section.

In case any significant post-conditioning prior to geological disposal is required, then the approval of the PSAR should also be followed by a period in which the construction of the post-conditioning building and the post-conditioning of the waste take place.

In principle, each PSAR should also be accompanied by the development of an EIA, which should also be approved by the competent environmental protection authorities before construction activities can begin.

Key milestones

For each of the 3 groups of waste identified above, a distinction can be made between the **project phase,** which covers the development and approval process of the corresponding PSAR (and the associated EIA), and the actual **disposal phase,** which covers the construction, operation and closure of the concerned repository section.

The basic planning of the disposal phase is driven by:

- The earliest date for the disposal phase, which is the date envisaged for the approval of the first PSAR (2025).
- The time of availability of the last disposal group (2075/2080), i.e. the very high level waste streams, which require a long cooling time of at least 50 years.
- The assumption of a separation in time of the construction and operation phase of any specific repository section. However, for actual implementation, a scheduling optimisation, involving performance in parallel of construction and operation activities, could be expected to occur.
- The assumption that there is no time period reserved between the implementation of the different repository sections for monitoring only. This, however, does not preclude monitoring activities in parallel with other activities, such as construction, operation and closure.
- Rules of thumb used for timing:
  1. site preparation and shafts: 10 years;
  2. construction of disposal galleries for a repository specific to a group of waste streams: 5 years, but 15 years for VHLW;
  3. operation (including sealing): limited to 10 years per group/section;
  4. closure of the overall repository and preparation for long-term institutional control: 10 years;
  5. the preparation of a PSAR or SAR necessary for the following phase is performed in parallel with the current phase;
  6. post-conditioning activities are also assumed to occur in parallel with other activities.

This results in the key dates given below. Since the difference between the full reprocessing and no further reprocessing scenarios is relatively small (considered to be less than 10 years), no difference has been made for this basic planning.

Basic planning of disposal phase

2025	:	based on the **first PSAR**, a construction license is granted
2025…2035	:	site preparation and construction of shafts
2035…2040	:	construction of galleries for disposal group 1
2040	:	based on the **first SAR**, an operation license is granted
2040…2050	:	**operational phase for disposal group 1**
2050	:	based on the **first "closure" SAR**, closure of repository section of disposal group 1
2050	:	based on the **second PSAR**, a construction license is granted for section 2
2050…2055	:	construction of galleries for disposal group 2
2055	:	based on the **second SAR**, an operation license is granted for section 2
2055…2065	:	**operational phase for disposal group 2**
2065	:	based on the **second "closure" SAR**, closure of repository section of disposal group 2
2065	:	based on the **third PSAR**, a construction license is granted for section 3
2065…2080	:	construction of galleries for disposal group 3
2080	:	based on the **third PSAR**, a construction license is granted for section 2
2080…2090	:	**operational phase for disposal group 3**
2090	:	based on the **third "closure" SAR**, closure of repository section of disposal group 3
2090	:	based on the final **"closure" SAR**, a closure license is granted
2090…2100	:	overall closure of the category B&C repository (filling and sealing of remaining galleries and access and ventilation shafts), followed by site preparation for long-term institutional control
2100	:	site ready for long-term institutional control

Table 1. Full reprocessing scenario times of availability for disposal and grouping of waste streams

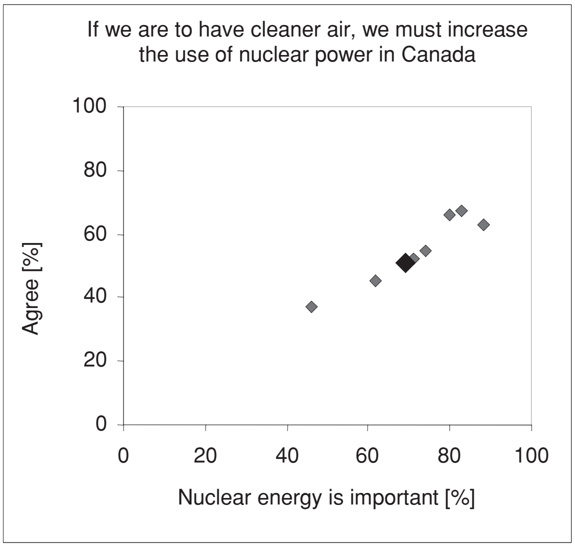
Cat.	Waste stream	Matrix	Total volume [m^3]	Year of availability	Group
HLW	Fission products from power/research reactors fuel reprocessing	glass	700	2080	**3**
	Technological waste from power/research reactors fuel reprocessing	–	1 150	2030	**2**
	Fission products from the former EUROCHEMIC reprocessing plant	glass	250	2010	**1**
	Technological waste from the former EUROCHEMIC reprocessing plant	cement	30	2010	**1**
MLW	Sludges from power/research reactors fuel reprocessing	bitumen	1 15	2020	**1**
	Sludges from the former EUROCHEMIC pilot reprocessing plant	bitumen	3 285	2020	**1**
	Solid waste from past activities	cement	950	2015	**1**
	Solid waste from the dismantling of power/research reactors	cement	1 070	2045	**2**
	Solid waste from other dismantlings	cement	45	2035	**2**
LLW	Long-lived waste from the MOX production	cement	1 700	2035	**2**
	Long-lived waste from other sources	cement	400	2010	**1**

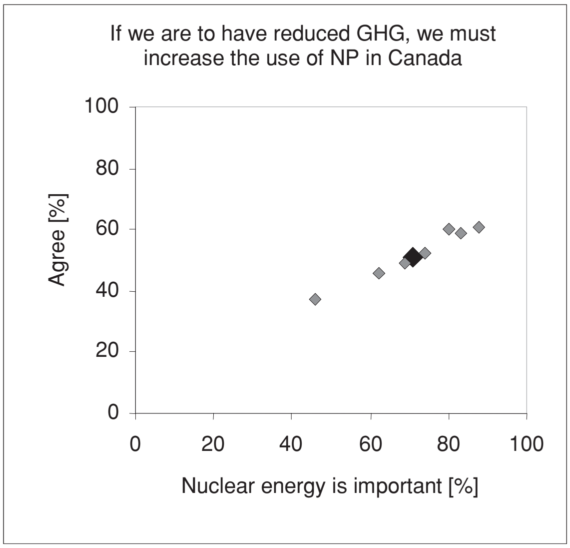
**Table 2. No further reprocessing scenario
times of availability for disposal and grouping of waste streams**

Cat.	Waste stream	Matrix	Total volume [m^3]	Year of availability	Group
HLW	Non reprocessed spent fuel	–	4 420	2075	**3**
	Fission products from power/research reactors fuel reprocessing	glass	76	2050	**3**
	Technological waste from power/research reactors fuel reprocessing	–	150	2020	**2**
	Fission products from the former EUROCHEMIC reprocessing plant	glass	250	2010	**1**
	Technological waste from the former EUROCHEMIC reprocessing plant	cement	30	2010	**1**
MLW	Sludges from power/research reactors fuel reprocessing	bitumen	1 15	2020	**1**
	Sludges from the former EUROCHEMIC pilot reprocessing plant	bitumen	3 285	2020	**1**
	Solid waste from past activities	cement	950	2015	**1**
	Solid waste from the dismantling of power/research reactors	cement	1 070	2045	**2**
	Solid waste from other dismantlings	cement	45	2035	**2**
LLW	Long-lived waste from the MOX production	cement	1 700	2035	**2**
	Long-lived waste from other sources	cement	400	2010	**1**

CANADA

Results of the IPSOS REID report on nuclear energy submitted to Natural Resources Canada in 2007





Key to graphs: Regions in Canada are indicated with solid markers in blue. The solid square indicates the Canadian average.

CZECH REPUBLIC

Legislative background

In 1997 the Act on the Peaceful Utilization of Nuclear Energy and Ionizing Radiation (the so-called Atomic Act) was approved by Parliament. This act (among others) established the Radioactive Waste Repository Authority (RAWRA), a state organisation. Radioactive waste management is realized on the following principle: State guarantees the safe disposal of all radioactive waste and an owner of radioactive waste shall bear all cost associated with its management.

The main responsibilities of RAWRA include:

- the preparation, construction, commissioning, operation and closure of radioactive waste repositories and the monitoring of their impact on the environment;
- radioactive waste management;
- providing for and co-ordination of research and development in the field of radioactive waste management;
- the drafting of proposals for the determination of levies to the nuclear account.

National status

In the Czech Republic there are two nuclear power plants, NPP Dukovany with 4 VVER 440/213 reactors in operation since 1985 and NPP Temelín with 2 VVER 1000 reactors since 2000. The short term low and intermediate level waste are disposed of at regional repository at Dukovany Site. The HLW waste and waste not acceptable to the existing repositories that will be generated in these NPPs, and that should be disposed of in deep geological repository (DGR) are listed in the following Table 1.

Table 1. Survey of HLW (post-processing volume) and spent nuclear fuel production

Source	HLW except SNF operation (m^3)	HLW except SNF decommissioning (m^3)	SNF (tHM)
EDU (1985-2025)	50	–	1 937
EDU (2085-2094)	–	2 000	–
ETE (2000-2042)	50	–	1 787
ETE (2090-2095)	–	624	–
Total NPP	**2 724**		**3 724**
Institutions (1958-2000)	80	5	0.2
Institutions (2000-2050)	150	50	0.3
Total institutions	**285**		**0.5**

Basic steps of spent fuel waste management in the Czech Republic

The spent fuel assemblies (SFA) are for some time cooled at the pools at each reactor. In NPP Dukovany at each of 4 reactors it is possible to store 683 SFA 7 years on average. At NPP Temelín, it is 672 SFA for 12 years.

The second step of SF management in the Czech Republic is dry storage technology of spent fuel. In Dukovany the technology with Casks CASTOR 440/84 supplied by Consortium GNS/NUKEM was chosen. Now the first storage at Dukovany NPP facility for 600 t is almost full, but a new facility of the same type for 1 340 t of spent fuel will be commissioned in 2006. At Temelin NPP the similar facility for 1 370 t of SFAs is under preparation. An international tender is expected to be open for the storage technology contractor. The time of storage depends on the licence for Castor casks in which SFAs are stored. The expected time of dry storage of SF assemblies is 60 years corresponding to the current license of Castor casks It is, however, supposed that the license can be prolonged.

At the moment a valid building licence is available for the back-up storage facility for SFAs on the Skalka site. The site is located some 60 km from the NPP Temelín. Site, and underground investigations were performed in the past; including an exploration gallery. Underground dry storage for SF is planned there. Facility is designed for 2 900 t of SFAs.

After the storage time, the spent fuel should be transported to a deep geological repository if it will be not decided to reprocess the fuel abroad. The deep geological repository is planned to be located in granite host rock. Granitoids are the favourable rock type in the Czech Republic. Due to problems with local acceptance, a decision was made by the Ministry of Industry and Trade in February 2004 to suspend all on-site characterisation work for five years. The Czech Government noted this decision in decree No. 550 of 2 June 2004 which also imposes on RAWRA the condition that geological work be concluded according to an approved plan of work. In 2005 the first phase of site characterisation stage has been finished on six sites. Now, the development of DGR is focused mainly on research of possible processes occurring in near field and far field of repository and preparation of safety cases.

Decision-making process

Decision-making process for spent fuel management in the Czech Republic is framework by the "Radioactive Waste Management Concept" that has been prepared in compliance with energy policy approved by Government Decree No. 50 of 12 January 2000.

The objectives of the Concept are as follows:

- to determine strategically justified, scientifically, technically, environmentally, financially and socially acceptable principles for radioactive waste and spent nuclear fuel management in the Czech Republic;
- to develop a basic system framework for the decision making of those authorities and organisations responsible for radioactive waste or spent nuclear fuel management in the Czech Republic;
- to communicate in straightforward way information concerning the long-term management of radioactive waste and spent nuclear fuel to organisations involved in this field and to the general public.

The Concept is based on an analysis of current developments and professional forecasts of future trends in the peaceful employment of nuclear energy and ionising radiation. It is based on fifty years of experience of Czech organisations involved in the disposal of radioactive waste and on proven practice, as well as on a modern and complex system of legal regulations that make it possible to perform individual activities in a safe way and which contains sufficient control mechanisms relevant to present-day conditions and into the future. The Concept also takes into account experience and best practice in radioactive waste management in other countries.

The Concept respects strategic government policy including

Energy policy

The Concept allows for the possible further development of nuclear energy. It proposes sufficiently flexible solutions, in terms of both technology and time for the back end of the fuel cycle, and the continuous disposal of operational radioactive waste from the energy sector.

State policy for the environment

The Concept respects the principles of sustainable development (e.g. it employs mechanisms to minimise the quantity of radioactive waste and addresses the security of radioactive waste up to the point when it becomes harmless).

Former government resolutions

Government resolutions recommended the construction of spent fuel storage facilities at nuclear power plants, in the area of waste management, recommended the disposal of radioactive waste in operational repositories and in the area of spent fuel management, the construction of a deep geological repository was recommended.

Basic principles of Radioactive Waste Management Concept

- Management of RAW and SF in the Czech Republic is provided for by authorised private entities and RAWRA and, if needed, the RAWRA will also provide extended services for the generators.
- Liquidation of low- and intermediate-level short-lived RAW in the Czech Republic is performed by their safe disposal in the existing near-surface repositories whose operation has been continually evaluated and economically optimised, one of the options to liquidate low- and intermediate-level long-lived RAW which does not meet an acceptance criteria of existing repositories and HLW is their disposal in DGR; before the facility is put into operation these materials will be stored with their generators or in facilities of the RAWRA.
- Technology procedures for RAW management and preparation to implement DGR in the Czech Republic have been in agreement with the legislative requirements and results of foreign research and technology developments. Simultaneously, possibilities of SF reprocessing are monitored and assessed, as well as the use of new technologies leading to reduction of SF volume and toxicity.
- The costs of activities associated with disposal of RAW and SF are paid from the nuclear account, a financial source created by generators of RAW and SF in agreement with the

Atomic Act and established government order, while the nuclear account as a part of the state financial assets and liabilities and is managed by the Ministry of Finance. This assures that the costs of disposal for wastes generated now will not be transferred to future generations.

- General public is kept informed about the Policy and about its fulfilment.

Radioactive Waste Management Concept

- allows for the possible further development of nuclear energy;
- respects the principles of sustainable development;
- declares the principles, objectives and priorities for achieving optimum RAW and SF management;
- sets the specific content of activities to legal regulation;
- provides a decision-making framework for generators of RAW and SF concerning their business and strategies;
- contains basic information about future intentions and priorities concerning radioactive waste and spent fuel management in the Czech Republic.

Main stakeholders in decision-making process

The Radioactive Waste Management Concept applies to the activities of following numerous interest groups and organisations affecting decision-making process.

The Czech Government and state authorities in general

By adopting the Concept the government declares the principles, objectives and priorities for achieving optimum radioactive waste and spent nuclear fuel management, to be implemented by individual ministries, including the Ministries of Industry and Trade, the Environment and Finance and other state institutions (e.g. Mining Authority). The decision-making process is governed mainly by Atomic Law, Mining Law, Construction Law and Act No. 100/2001 Coll., on assessment of impacts on the environment.

The State Office for Nuclear Safety (SONS)

The Concept sets out the specific content of those activities subject to legal regulation, thereby providing support for the state supervision of radioactive waste and spent nuclear fuel management.

The Radioactive Waste Repository Authority and its supervisory Board (RAWRA)

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

Generators of radioactive waste and spent nuclear fuel

The Concept provides a decision-making framework for generators of radioactive waste and spent nuclear fuel concerning their business or production strategies. The storage and shipment of spent nuclear fuel and HLW is the responsibility of generator (Czech Power Company – ČEZ). ČEZ or SONS can decide whether and when the SFAs are becoming waste or will be sent to reprocessing; the term of 2065 was proposed on the basis of ČEZ plans as time for starting DGR operations and accepted by RAWRA responsible for DGR preparation.

Institutions involved in the development of methods for the disposal of radioactive waste and spent nuclear fuel

Using the Concept, research and scientific institutions, universities and other organisations can allocate capacity and systematically prepare for the fulfilment of any requirements arising from the implementation of the concept.

The general public

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

The general public engagement in decision-making process

Formal engagement

The formal public engagement in the approval of HLW disposal is possibility of public to express their comments in various stages of HLW waste management facilities development in compliance with Act No. 100/2001 Coll., on assessment of impacts on the environment (EIA) and some other formal procedures needed for obtaining approval for ground investigation, construction and operation of disposal facilities. The EIA documents are available to the general public, for example on the websites of the government institutions, e.g. Ministry of the Environment. The EIA documents are mailed to municipalities, local government authorities and administration bodies affected by the planned project and, in agreement with Article 4 of the Espoo Treaty and Section 13 of Act No. 100/2001 Coll. These EIA documents are in conformity with Article 5 of the Espoo Treaty and Section 13 of Act No. 100/2001 Coll., discussed in meetings before formal documents approval. A representative from general public is not, however, a direct participant of formal legislative procedure leading to the approval of EIA documents.

Informal engagement

Informal engagement of the general public in development of HLW disposal facilities can have, however, an important effect on development and realisation process as follows from the fact that when performing ground investigations in connection with potential DGR development mayors and population of the concerned municipalities showed strong opposition against potential development of DGR. For this reason Ministry of Trade and Industry and RAWRA reached an agreement approved by the government and the ground investigations in the locations will not continue until 2009.

Lessons learnt

Timing of HLW waste disposal in the Czech Republic will be affected by a number of factors and decisions including following ones:

Technical factors/decisions

- Decision on construction of a new nuclear source considered now in the Czech Republic.
- Decisions on SFAs reprocessing, partitioning, transmutation instead of direct disposal.
- Lifetimes of storage facilities and SFA casks (the current licence for Castor Casks is 60 years) connected with SONS approval.

Safety factors

- Impact of long-term operation of storage facilities on public and workers (primarily from the regular monitoring and possible changing of seals in Castor casks).
- Evaluation of a risk of abnormal events occurrence on surface storage facilities (terrorist attacks, earthquakes, plane crash).

Economic factors

- Price of long-term monitoring of storage facilities.
- Price of uranium.

Socio-political factors

- Availability of sites for storage and disposal against public resistance supported by ecological movements and some politicians.

It seems now, however, that the most important factor is local public resistance against DGR development in their municipalities as was already mentioned above. Analysis of existing information form public surveys, and secondly initial discussion with selected stakeholders within EC project RISCOM II in the Czech Republic showed that knowledge about nuclear waste issues is poor, but that there is a real interest among the public to get more information. Negative attitudes among local representatives to a repository arise mainly because it is seen as spoiling the area with negative influences on tourism and real estate values. The study concluded that the national policy needs to be transparent, the role of the local administration must be clearly defined and that local representatives should be included into the debates and activities.

FRANCE

UPDATES ON MAJOR RECENT DEVELOPMENTS
39TH RWMC MEETING 15-17 MARCH 2006

Main events and national policy

In 2005, new developments on radioactive-waste management in France were marked mostly by the preparation of the 2006 milestone specified in the act of 30 December 1991. A bill on radioactive waste management has been prepared by the Government at the beginning of 2006 and will be forwarded to the French Parliament before the Parliamentary debate planned at the beginning of April 2006. The bill draws from the results of the 15 years of research performed by Andra and the CEA on "partitioning and transmutation of long-lived radionuclides", "deep geological disposal" and "conditioning and long-term interim storage".

Main elements for the preparation of the bill were:

- The publication of a report in March 2005 by the Parliamentary Office for the Assessment of Scientific and Technical Options (OPECST) after a series of hearings of the different stakeholders.
- The organisation of a public debate on radioactive waste management by the "*Commission Nationale du Débat Public*": 13 public meetings were held all around France from September to January 2006. The final report was published in February 2006.
- The review of Andra's *Dossier 2005* by ASN and its technical supports IRSN and GPD (standing group of experts on radwaste disposal) and the peer review of *Dossier 2005 Argile* performed in parallel under the aegis of NEA/RWMC leading to the advice of ASN to the Government published on 1 February 2006.
- A global evaluation report on the three areas of research stemming from the hearings performed by the National Review Board.
- The draft National Plan for Management of Radioactive Waste and Reusable Material established by ASN.

In parallel, the French Government has approved a bill, on 22 February 2006 that would set up an independent nuclear regulatory authority to increase confidence in the nuclear option. The measure would set up a "High Nuclear Safety Authority" (HASN) in charge of regulating nuclear safety and radiation protection and providing public information. The new HASN would be headed by a college of 5 commissioners.

National Plan for Management of Radioactive Waste and Reusable Material

A National Plan for Management of Radioactive Waste and Reusable Material (PNGDR-MV) led by ASN was launched by the Ministry of Environment in June 2003. It involves the main stakeholders including radioactive waste producers, Andra, elected representatives and associations. A draft of the

PNGDR-MV was finalised in July 2005 and put on the ASN website up to December 2005 for public comments. The OPECST proposed in its report of March 2005 that the law on radioactive waste management endorse the PNGDR-MV.

Research on HL-MLW disposal

The deadline of 15 years of research prescribed by the Law of 30 December 1991 is soon coming to an end. On 30 June 2005, the Minister for Higher Education and Research and the Minister for Industry received the CEA and Andra reports on the investigations that were carried out and on their findings.

Both reports present the results of the 15 years of research performed in accordance with the law on the different methods for the management of HL-MLW, focusing on three main areas:

- partitioning and transmutation of long-lived elements;
- disposal in a deep geological formation;
- long-term conditioning and storage.

Being responsible for investigations on deep geological disposal, Andra submitted two reports on disposal options in clay and granite formations: the *Dossier 2005 Argile* and the *Dossier 2005 Granite*, respectively. The first report covers the overall information gathered on waste packages and on the Meuse/Haute-Marne Site (Bure Site), as well as studies on repository design and safety assessments. Due to the absence of a relevant site, the second report includes the same type of documents on a generic basis concerning granite formations.

Both reports may be downloaded in French from Andra's website. They should be available in English by the end of June 2006.

http://www.andra.fr

Activities at the Meuse/Haute-Marne Laboratory continued and the junction of the drifts running between the shafts was achieved in December 2005.

The characterisation programme currently performed in the drifts being excavated and the experimental programme were carried out according to schedule. A large number of experiments are ongoing in order to confirm or to complete many acquired data, especially with regard to the mechanical behaviour of the rock, the characterisation of the excavation disturbed zone (EDZ tests), plug-sealing tests (key experiments) and the diffusion of radioelements.

Review of Dossier 2005 Argile

After the presentation of both *Dossiers* to the Ministers, the second half of 2005 was marked by the review of those reports, the exploitation of the first results obtained at level -490 m of the Meuse/ Haute-Marne Laboratory and reflections on a potential programme after 2006.

The *Dossier 2005 Argile,* in its June 2005 version, was the subject of a threefold review at the request of French public authorities: the first, by the National Review Board (*Commission nationale d'évaluation* – CNE), as prescribed by the Law; the second, by the Nuclear Safety Authority (*Autorité* *de sûreté nucléaire* – ASN) on account of its prerogatives, and the third, by a group of international experts under the aegis of the OECD Nuclear Energy Agency (OECD/NEA) at the request of Andra's supervisory ministers. In the case of the *Dossier granite,* the report was also assessed by the CNE and ASN.

The June version of the report was also reviewed and commented by Andra's Scientific Board. Those comments were taken into account to the fullest extent possible and the Board's concluding note was included in the final version of the report published in December 2005. Prior to those exchanges, key French scientists as well as representatives from Andra's foreign counterparts were solicited during the preparation of the reports themselves with a view to providing a critical review of the main documents forming the *Dossier 2005 Argile*.

National Review Board

The National Review Board followed constantly the progress of the research programme and published a yearly report accordingly. On a more specific basis, it also heard Andra on 9-10 November 2005 on the results of the *Dossier 2005* and on 14 December 2005 on the new findings achieved at the underground laboratory.

The report on the three regulatory research areas was submitted to the government at the end of January 2006. More particularly, it recommends that disposal be considered as the reference solution. It advocates that the work conducted in that area compare with "the best international standards". The CNE believes especially that those investigations have not only demonstrated that the Callovo-Oxfordian formation constitutes a "remarkable environment, both in quality and in quantity", but also that the rock present on the Bure Site is highly homogeneous and is free of water-conducting faults.

CNE recommendations for the future programme deal notably with the continuation of ongoing experiments in the underground laboratory, which are considered essential, and the survey of the transposition zone in order to verify the presence of sizeable areas compatible with the implementation of a repository and having similar favourable characteristics to those observed at Bure. The Board also recommends that research activities be addressed as to integrate social and economic issues relating to the insertion of a disposal project in its host area. It also recommends that a demonstrator programme be installed in order both to verify the performance of the different repository components and to test the reversibility of proposed concepts.

The CNE drew a list of suggested themes to be furthered during the next phase of the programme, with priority being given to the three following themes:

- radionuclide migration within the rock, with particular emphasis on the study of issues associated with the variability assessment of rock properties at various scales;
- the future of the corrosion gases within the repository and, especially, its impact on the resaturation phase of the repository;
- the efficiency of the plugs in relation to the long-term evolution of the EDZ.

The CNE also feels that there is a reasonable probability that a survey process may be fully completed in order to select a suitable site.

Nuclear Safety Authority

Upon the request of ASN, the French Institute for Radiation Protection and Nuclear Safety (*Institut de radioprotection et de sûreté nucléaire* – IRSN) reviewed both the *Dossiers Argile* and *Granite* from August to November 2005. The exercise gave rise to a large number of meetings and exchanges of questions. The Institute published an assessment report that was submitted to the Standing Group of Experts on Waste at its meeting of 12-13 December 2005. The final opinion of the Standing Group was sent officially to ASN on 15 December 2005. Confirming the IRSN's report, it issued a very positive opinion about the case *("the Standing Group emphasises that the* Dossier 2005 Argile *provides a thorough and high-quality coverage of the case and constitutes a significant advance").* In addition, the Standing Group *"issues a favourable opinion on the assessment made by Andra and believes that the implementation of a radioactive-waste repository in a clay formation, for which ongoing studies are carried out through an underground laboratory at Bure, is feasible. If Parliament were to adopt the implementation of a radioactive-waste repository in a geological formation as a policy decision, the Standing Group feels that no safety-related argument would hinder the selection process of a suitable repository site within the transposition zone selected by Andra."*

The Standing Group also formulated recommendations with a view to preparing a case report accompanying the authorisation application dealing with the continuation of the survey programme of the sector, the clarifications to be brought to the specifications of the different repository components, scientific tests and technological demonstrations to be performed, etc. That opinion and the IRSN report were made public at the end of January 2006, which marks a *première* for such an assessment.

Furthermore, the IRSN submitted its opinion to the ASN on the *Dossier Granite*. From the exchanges of views with the IRSN emerges the opinion that its content is positive and that Andra has fulfilled the overall demands of the Standing Group as formulated in 2003 and that the Agency has drawn the maximum benefit from the available data in the absence of a suitable investigation site.

On that basis, ASN submitted its own opinion to the government on the management of high-level and long-lived waste. That opinion, made public on 1 February 2006 (http://www.asn.gouv.fr), states that *"deep geological disposal appears unavoidable as a final management solution"*. ASN believes that, if Parliament were to adopt the implementation of a geological repository as a policy decision, it would be reasonable to seek a suitable area for disposal purposes in the transposition zone. ASN also feels that reversibility is necessarily a limited process in time and recommends a stepwise management of the repository.

ASN also formulates recommendations for the future research programme. Consistent with the CNE recommendations, it stresses particularly the mechanical behaviour of the repository in relation to plugs, the management of gases and the need for demonstrators with a dual view to verifying the performance of structures and demonstrating reversibility. It emphasises also the need for further studies on operational safety.

Concerning P&T of long-lived radionuclides ASN says that it could not be applied industrially before 2040-2050, would leave residual waste and would not be applicable, for reasons of radiological protection, safety and cost, to already conditioned waste. As for long interim storage, above ground or just below ground, ASN says its safety would require continual active monitoring that cannot be guaranteed for more than a few hundred years, placing an unacceptable burden on future generations.

With respect to the search of a second laboratory on a granitic site ASN said that although Andra's *dossier* was of good quality it would take much more research to qualify any granite site in

France, and seeking a second site does not appear to be a priority from a safety viewpoint, notably because of the favourable properties of the Bure site.

ASN outlined a possible schedule for licensing of a repository as a "basic nuclear installation" (INB), i.e. a facility similar to a nuclear plant or a fuel cycle facility. ASN said that between now and 2011, Andra would continue research in the Bure laboratory and look for the best specific site in the area to build a deep repository. Between 2011 and 2016, Andra would submit its application and the safety authority would review that application. Assuming issuance of the license at the end of that period, in 2016, Andra would build the repository between then and 2023, when the facility could begin to operate.

OECD/NEA Peer Review

The review of the *Dossier 2005 Argile* by the International Review Team (IRT) set in place by the OECD/NEA was based on the Terms of reference set by Andra's supervisory ministries in order to channel the review according to the following themes: the long-term safety strategy, the quality of the scientific and technical bases of the case report, the reversibility approach, the relevancy of the conclusions, as well as the clarity of the documentation and of its structure. The IRT consisted of the same experts who assessed the *Dossier 2001,* with the additional support of two new specialists in geology and engineering, respectively.

The orientation seminar held in May 2005 helped experts to familiarise themselves with the structure of the documentation and of its overall approach. Question-and-answer exchanges took place from August through October 2005. The closing seminar held in November 2005 clarified the pending issues. The first "*provisional findings*" of the review were issued on the last day of the seminar and confirmed in a letter sent to Andra's supervisory ministries and to the ASN at the end of November. They included a special note certifying that the recommendations formulated at the end of the previous review had been implemented, that the programme compared fully with best international practices and proved to be the most advanced in several fields. Andra's reversibility approach was considered as innovative without compromising the safety of the repository. The IRT concluded that *"the* Dossier 2005 *successfully establishes confidence in the feasibility of constructing a repository"*.

The IRT also formulated recommendations concerning the pursuit of hydrogeological models of the site through complementary boreholes, diffusion experiments over longer timescales, a more thorough integration of gas issues in the definition of repository structures and the need for technological demonstrators in order to validate concepts.

The IRT report will be presented at the RWMC meeting in March 2006.

Public Debate

The French government decided to organise a public debate with a view to providing the necessary information concerning the preparation of a new draft law to be tabled before Parliament in 2006. The organisation of the debate was entrusted to the National Commission on Public Debate (*Commission nationale du débat public* – CNDP).

Mission and role of the National Commission on Public Debate

As an independent administrative authority, the CNDP is responsible for organising public debates on the timeliness, the objectives and the main characteristics of large development operations in the national interest of the State, territorial communities, public establishments and private individuals. The CNDP's mandate is to promote both information dissemination and consultations in the case of all important projects.

The joint request of the Minister of Ecology and Sustainable Development and of the Minister of Industry dated 16 February 2005, as well as the associated case report, led the CNDP to fulfil its mandate with regard to the management of radioactive waste. Following its initial review of the case, the CNDP organised a debate from September 2005 through January 2006 after the public had an opportunity to read the report. In accordance with the Ministers' request, the CNDP issued its conclusions in mid-January 2006. The organisation of the debate was entrusted to an *Ad Hoc* Commission on Public Debate (*Commission particulière du débat public* – CPDP) for radioactive waste management.

The debate provided an opportunity for all actors to be heard, gathered many specialists and stakeholders, together not only with the requesting ministries, but also with citizens' associations and, naturally with organisations in charge of research, production and control involved in the nuclear fuel cycle. The debate also provided an opportunity to any individual who wished "to be informed through discussions".

Organisation of the Public Debate

The public debate was first announced at a press conference, followed by a press release. It extended from 12 September 2005 to 13 January 2006, and included the four following phases:

- public hearings in September;
- scientific and technical days in October;
- "Democracy and Radioactive Waste" discussion forums in November;
- synthesis and closing, in December and in January.

Thirteen public meetings were held and gathered approximately 3 000 attendants in 11 different French cities. More than 60 hours were dedicated to meetings. Answers were provided to the 500 questions or so raised by participants and experts, including six foreign contributors. Every meeting was announced in the media. An abundant documentation was distributed to participants and on the website created for that purpose.

The following statistics provide a clearer picture of the endeavour: participation of 3 000 attendants, distribution of 600 000 information documents and 16 000 case reports and the visit of 54 000 people at the exhibit organised at the Science and Industry Museum (*Cité des sciences et de l'industrie*) in Paris. The website recorded 15 000 visitors and the debate was covered by 370 media items.

Results of the Public Debate

The first element to be noted is that the entire debate took place under very good conditions until the very end, although the last concluding meetings were cancelled in favour of a single meeting in Lyon. The prerequisite conditions submitted by the opponents to the repository project did not prevent the actual discussion among parties of all venues, and a true public debate was held in a serene climate and in a spirit of mutual listening and dialogue. The public at large was present in the regions directly concerned by the project and particularly in the Meuse and Haute-Marne Departments, but attended to a lesser degree the special days organised at the Paris Science Museum or the other meetings. Such attendance levels reflect the higher interest of the populations living close to the laboratory.

In spite of some heated discussions, there were no comments intended to create or to stir up fears.

The confidence deficit in public authorities or in scientists was reiterated on several occasions. In the first case, comments referred to the lack of information, the proliferation of actors and the resulting confusion between their respective roles, as well as the need for an independent authority. In the second case, some participants expressed their doubts about the statements made by scientists whose impartiality seemed questionable.

The Chairman of the CNDP also emphasised the remarkable implication of the Ministry for Industry as the driving force of the project. Always present at all phases of the debate, the Ministry did not only respond rapidly and precisely to all questions, but also acted in all occasions with an outstanding sense of attention and openness. The Ministry also pointed out that the conclusions of the debate were taken into account in the preparation of the draft law.

Main findings drawn by the **Ad Hoc** *National Commission on Public Debate*

The first lesson to be drawn from the debate is the request made to see the new law address all radioactive waste and recoverable materials. If that should be the case, the National Inventory and the National Management Plan prepared by Andra and the ASN, respectively, would need to be confirmed.

Concerning more particularly high-level and long-lived waste, the idea to take advantage of the time required to develop a stepwise solution and to schedule periodical milestones emerged from the exchanges and could be summarised by the following statement made by the spokesperson from the Ministry of Industry: “to advance without taking shortcuts, to assess in complete independence and to have the possibility to stop, if need be.” The proposal for a permanent-storage concept has also appeared and would not represent a temporary solution pending the implementation of a repository, but rather another long-term solution.

In relation to the new law, the CNDP proposed both the continuation of experiments on geological disposal and the construction of a permanent storage prototype. Such a solution would allow benefiting from an alternative option and from additional time in order to take ethical considerations into account until 2020.

A high demand for information and dialogue, as well as for multidisciplinary expertise, has also been expressed. Public information and participation are recognised as condition for confidence-building and as a safety factor. At the local level, the CNDP suggests that the role of local information committees (*commission locale d’information*) be confirmed and clarified and that its financial means be determined.

From an ethical standpoint, the request referred in many instances to the principles of justice, equity and balance not only between generations, but also between territories. In the latter case, it should be pointed out that the request for the development of territories concerned is based on partnership and implies the participation of the large utilities. The presence of an active and vigilant population also represents a safety guarantee for the waste repository locations.

The French version of the full text of the report, together with the various documents and proceedings of the public debate, may be downloaded from the CNDP's website:

http://www.debatpublic-dechets-radioactifs.org/

Situation in March 2006 and prospects

The draft law on radioactive waste management is scheduled to be tabled before Parliament and is expected to be adopted during the summer of 2006.

According to the conclusions of the review of the *Dossier 2005* and the lessons learnt from the public debate, chances are that the new law will address all radioactive-waste categories. With regard to high-level and long-lived waste, the repository principle is expected to be adopted. However, its implementation would still require the future results of the Meuse/Haute-Marne Underground Laboratory to be confirmed and an authorisation application to be submitted to regulatory authorities within the next decade in order for its commissioning to be effective around 2025.

GERMANY

Background

In the fifties, the German Federal Government came to the decision to peacefully use the nuclear energy and to develop national industry capacities to meet the needs for the establishment of a complete nuclear fuel cycle. In the following years, also research capacities located in nuclear research centres, special institutes or universities were installed. In parallel, the legal framework and institutions for licensing and inspection of nuclear facilities were created.

Relatively early, i.e. already in the mid-sixties, the questions arising from the appearance of nuclear waste had been addressed to. The planning assumed reprocessing of spent fuel from the nuclear power plants and vitrification of the HLW. Also very early the Federal Government decided that all radioactive waste should be disposed of in the deep underground within the national territory. Neither the shallow-land-burial, sea dumping and disposal abroad were excluded. For the disposal within Germany repositories should be constructed in a salt diapir[1] of which more than a hundred occur in the North German Lowlands.

The German Federal Government, the utilities, and the nuclear industry were in agreement that the construction and commissioning of repositories should be carried out as early as possible. This tenet is still acknowledged until today, although meanwhile many changes of the political, societal, legal, and economic situation have taken place and thus, the timetable for the implementation of a HLW repository had to be amended correspondingly. At present, a target date for the start of disposal around the year 2030 is provided for.

Milestones of the implementation process for a HLW repository in Germany

The implementation of a HLW repository located in Germany is a process which was initiated simultaneously with that of the nuclear energy use and which was based on a clear and straightforward strategy. This process should have led to a start of operation in the nineties. Nevertheless, so far no HLW-repository exists in Germany, and the timing of the actual planning based on revised site selection concepts assumes a start of operation in the year 2030. In the past, the following main steps took place in the course of this implementation process.

In 1963, the Federal Office for Geosciences and Natural Resources (BGR) recommended salt formations as host rock for the disposal of radioactive waste. This recommendation was only founded by geological and technical arguments. Since then, all concepts for a HLW-repository in Germany which have been developed in the following decades only considered salt diapirs as host rock. This implied a considerable streamlining of the site-selection process and a reduction of the regions to be considered.

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1. Diapir: an anticlinal fold in which the overlying rock has been pierced by material from beneath.

In 1965, the Federal Government purchased a disused salt mine (the Asse Mine) for R&D work related to geological disposal in rock salt. In that frame, since 1968 almost all LAW (42 000 m³) accrued in Germany and additionally 1 300 ILW-drums have been emplaced (without any intention of retrieval) until 1978 when the legal base for this practice forfeited after an amendment of the German Atomic Act in 1976. Since 1979, the Asse Mine was merely used as underground research laboratory (URL). In the former GDR, a similar facility for the disposal of LLW came into operation (the ERA Morsleben) in 1978. This facility was closed for disposal in 1998.

In 1974, the Federal Government first announced the concept of an "Integrated Waste Management Centre" which should be implemented together with the nuclear industry. This centre should mainly comprise an interim storage facility, a reprocessing plant, and the underground final repository. This concept implied that the site-selection process for the whole centre was controlled primarily by the criteria for the repository.

In 1975, scientific investigations were started on the suitability of a disused iron ore mine (Konrad Mine at Salzgitter, Lower Saxony) primarily for the disposal of heavy and large decommissioning waste forms. This scope was later broadened to include all radioactive waste with negligible heat generation.

With the amendment of the German Atomic Act of 1976, the Federal Government became responsible for the construction and operation of the nuclear waste repositories, whereas the costs for the implementation of this concept according to the cost-by-cause-principle are to be paid by the utilities. Subsequently, a so-called "Integrated Waste Management Concept" was agreed between the Federal Government and the Federal States ("Länder") in 1979. This concept should allow the continuation and extension of nuclear power use. This agreement included that:

- For the limitation of the interim storage capacity for spent fuel, a reprocessing plant should be built as soon as possible. At the same time, the possibility of alternative waste management strategies, like direct disposal of spent nuclear fuel, should be investigated.
- Exploration and investigation of the Gorleben salt dome located in the Federal State of Lower Saxony should proceed expeditiously in order to implement a repository, if appropriate.
- The technical facilities for the selected waste management strategy including the repository should be ready for operation before the year 2000.

In 1977, the responsible Federal Authority submitted an application to initiate the licensing process for a repository to be built in the Gorleben salt dome. The site is located close to the Elbe River next to the border of the former German Democratic Republic. The selection was done in consent between the Federal Government and the State of Lower Saxony after a screening process implying geological as well as political and economical criteria.

In 1982, the Federal Government issued the "Safety Criteria for Nuclear Waste Repositories" with a dose criterion of 0.3 mSv/y for individuals of the public after closure. These criteria are still in force, although a proposal for actualisation was compiled in recent years.

In 1982, the "*Gesellschaft für Strahlen- und Umweltforschung*" (GSF) published the summary report on its investigations at the Konrad Mine showing the feasibility of the disposal of radioactive waste with negligible heat production in compliance with the German repository safety criteria. Based on this study, the responsible federal institution PTB submitted a license application to the State of Lower Saxony for a repository with an emplacement capacity of 650 000 m³ of LLW/ILW. This implied a change of the national disposal strategy that subsequently envisaged two repositories. The second repository for the heat-generating waste should be implemented at the Gorleben site.

After a modification of the legislation related to nuclear waste disposal in 1994, the direct disposal of spent nuclear fuel and the emplacement of HLW from the reprocessing became options of equal rank. Direct disposal was taken into account for the further planning of the Gorleben Project.

In 1998, a new Federal Government was elected having a mandate for the nuclear power phase out. In June 2000, the Federal Government and the utilities came to an agreement on the execution of this change in energy policy ("*Konsensvereinbarung* – Consensus Arrangement"). Among others, the stipulations include a stop of the reprocessing and the implementation of interim storage facilities for SNF at the NPP sites. The existing above-ground interim storage facility at Gorleben will only accept the vitrified HLW returning from reprocessing in France and the United Kingdom. The licenses for the interim storage facilities are temporary and permit an operation for 40 years. An explicit purpose for this limitation is to maintain the necessity and the efforts for the implementation of a HLW-repository in Germany.

At the same time, the Federal Government decided to impose a moratorium against the investigations at the Gorleben site of at least three, but not exceeding ten years, despite the fact that the site investigations carried out so far had not revealed any prohibitive features. This moratorium should not imply an abandonment of the Gorleben project, but in fact some technical and conceptual particular questions should be clarified within this period. Additionally, the site selection criteria for a repository with saline, granitic and argillaceous host rock should be revised. With these criteria, a new site selection process for the German HLW Repository will be initiated, in which the Gorleben site will be comprised among others.

Against this background, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) established the Committee on a Site Selection Procedure for Repository Sites (the "AkEnd") in 1999. The recommendations of the Committee shall support the Federal Government in the performance of its task to implement a nuclear waste repository. The Committee had been commissioned to develop a traceable procedure for the identification and selection of a site for the disposal of all types of radioactive waste in Germany. The BMU specified the objectives as general requirements for the development of the procedure, that: 1) all radioactive waste shall be disposed of in deep geological formations in Germany; 2) for the disposal of all types and quantities of radioactive waste, only one repository is sufficient; and 3) this repository should be operational from 2030 onwards.

In December 2002, the AkEnd delivered the proposal for a site selection procedure for repositories in Germany. According to the AkEnd, the Federal Government's aim to have a repository ready for operation by the year 2030 is very ambitious, however, the selection procedure permits the identification of sites for underground exploration by 2010. This would require rapid legitimisation and implementation of the selection procedure.

In June 2002, i.e. 20 years after the application, the State of Lower Saxony submitted the license ("*Planfeststellungsbeschluss*", official approval of a plan) for the implementation and operation of the planned Konrad repository to the Federal Agency BfS. Due to legal actions of concerned individuals and municipalities, the BfS at first made no use of this license and the conversion of the mine was correspondingly postponed.

With the decision of the Federal Administration Court of April 2007 the Konrad license became final and absolute and the Federal Republic is obliged by the Atomic Act to prepare the conversion of the Konrad Mine into a repository for waste with negligible heat generation. The Federal Government has declared that there is no alternative to the Transposition of this judicial decision, but that will not affect the discussion for Gorleben as potential site for a HLW repository.

Summary

From the first planning of a nuclear waste repository in Germany which was initiated in the sixties until present it can be stated that at all times the intention prevailed that this facility should be implemented as soon as possible, provided the safety requirements are met. This general consent existed and still exists between the majority of the public, the Federal Government, the political parties, the waste producers, and other involved groups and was never seriously disputed. Correspondingly, the successive Federal Governments with their responsibility for nuclear waste disposal have always tried their very best to fulfil this obligation. Basically, there is an agreement between the utilities and the Federal Government about the financing of concrete repository projects so that this work was never impaired by financial problems.

In retrospect, many reasons can be identified that caused the delays in the German HLW repository programme. However, there was never an explicit or definite decision on a fundamental revision of the disposal concept or a postponement of the disposal programme.

JAPAN

Current status of utilisation of nuclear energy

Overview

In Japan, 40 years have passed since research, development and utilisation of nuclear energy began, and various activities are presently ongoing. Outline of the current status as of March 2005 is as follows.

Operation of the first commercial nuclear power reactor in Japan started in 1966. Following the 1973 oil crisis, nuclear power plants were built actively, and now a total of 55 commercial nuclear power reactors are in operation. One reactor is at the decommissioning stage. Nuclear fuel cycle facilities related to commercial power generation, including 2 enrichment facilities, 4 fuel manufacturing facilities, 2 reprocessing facilities, 2 disposal facilities are in operation or under construction. In addition, sixteen research reactors are in operation at national and private institutes and universities.[1]

Nuclear power generation – Basic concepts

It is expected in pursuit of optimum energy supply mix for Japan in accordance with the characteristics of various energy sources that nuclear energy generation continuously contributes to the stable energy supply and to the measures against global warming. Therefore, it is appropriate to aim at maintaining or increasing the current level of nuclear power generation (30 to 40% of the total electricity generation) even after 2030. In order to achieve this, it is logical to make the followings as guidelines for the promotion of nuclear power generation in the future:

1. Pursue optimal utilisation of existing nuclear power plants on the premise of safety assurance, and undertake strenuous efforts in building new plants based on the underlying premise of the understanding of the public including local residents.
2. Prepare advanced models of the current LWRs for the replacement of existing nuclear power plants, which will start around 2030. Large-size LWRs are a prime candidate from the viewpoint of enjoying scale merit, though standardised medium-size LWRs may be an option depending on its economy and the size of need for additional capacity and the trend of balance between supply and demand of each electric utility.
3. Strive for the commercial use of FBRs from around 2050 on the premise of meeting the necessary conditions, including its economic viability, the progress of nuclear fuel cycle projects for LWRs while considering the situation of supply and demand of uranium and thus promote efforts for commercialisation reflecting the results of the "Feasibility Study on Commercialized of Fast Breeder Reactor Cycle System" and the operation of "Monju." The

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1. *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, October 2005, Government of Japan.

time period when the requirements of introduction of FBR system are satisfied may be brought forward or even delayed. If it is delayed, the introduction of advanced LWRs will be continued until conditions are fully met.[2]

Basic policy of utilisation of nuclear energy and current status of its management

The research, development and utilisation of nuclear energy in Japan are conducted solely for peaceful purposes in accordance with the Atomic Energy Basic Law. The Atomic Energy Commission (AEC), established on the basis of the law, plans, deliberates and makes decisions on national policies relating to the utilisation of nuclear energy for peaceful purposes. In order to clarify the fundamentals for the utilisation of nuclear energy and its development, the Commission has formulated a total of nine long-term plans for research, development and utilisation of nuclear energy (long-term plans) since 1956, one approximately every five years. The new policy plan was formulated as the Framework for nuclear energy policy (Framework) in October 2005. Based on the policy stated in the Framework, the Agency for Natural Resources and Energy (ANRE) of METI and MEXT establish implementation plans for utilisation of nuclear energy for power generation and related fuel cycle activities, and implementation plans for utilisation of nuclear energy in science and technology and radioisotopes, respectively. Fundamental laws to ensure safety in the utilisation of nuclear energy and radiation are the Law for the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (the Reactor Regulation Law) and the Law Concerning Prevention from Radiation Hazards due to Radioisotopes, etc. (the Radiation Hazards Prevention Law), both of which are based on the Atomic Energy Basic Law, and the Medical Care Law, the Pharmaceutical Affairs Law and the Clinical Laboratory Technicians and Health Laboratory Technicians Law (the latter three are referred to hereafter as the Medical Care Law, etc.). These laws and their related regulations have been amended, as appropriate, as the utilisation of nuclear energy and radiation expands and diversifies.

The NSC, established on the basis of the Atomic Energy Basic Law, plans, deliberates and makes decisions on policies aimed at ensuring the safe utilisation of nuclear energy. As the regulatory bodies responsible for ensuring safety within their particular area of competence, NISA of METI, the STPB of MEXT and the PFSB and the HPB of the MHLW regulate and issue guidance on relevant activities.

Operators of nuclear facilities conduct their activities under the policies and the regulations mentioned above. Japan Nuclear Energy Safety Organization, a technical support organisation to NISA, was founded in October 2003. In April 2004, NISA established the Nuclear Safety Public Relations and Training Division within NISA and assigned the Regional Public Relations Officer for Nuclear Safety, in order to promote public relations [14].

Current status of radioactive waste management

The basic policy on the radioactive waste management is that the current generations, who receive the benefit of nuclear energy, should bear the responsibility to manage the resulting waste generated in the research, development and utilisation of nuclear energy, and should make continued efforts at promoting radioactive waste disposal. The operator of the facility that produces waste has the primary responsibility for safe processing and disposal of the waste, and based on the principle, they prepare and implement their plans with consultation of other relevant organisations. Meanwhile, the government regulates, and issues guidance to, the producers, ensuring that waste processing and disposal are carried out appropriately and safely. Radioactive waste is classified into two categories.

2. *Framework for Nuclear Energy Policy*, 11 October 2005, Japan Atomic Energy Commission.

One is high-level waste (HLW) generated from spent fuel reprocessing, and the other is low-level waste (LLW). The LLW is sub-classified according to origin (radionuclide composition) and level of radioactivity. The AEC decides on the basic policy for disposal of radioactive waste. Based on the classification, the NSC decides fundamental concept for safety regulations on radioactive waste disposal, upper bound of radioactivity concentration in disposal and the guidance on safety assessment of radioactive waste disposal facilities. METI and MEXT establish relevant regulations.[3]

It is important for the Government and operating entities to promptly clarify their disposal method and to work on the implementation of the disposal, so as not to delay the understanding of the people about nuclear energy administration, which might eventually hinder smooth progress in the research, development and utilisation of nuclear energy.[4]

LLW generated in reactors, reprocessing facilities, etc., is processed and temporarily stored in storage facility in these facilities and then sent to disposal facility. LLWs below the upper bound level from power reactors are being transferred to the waste disposal facility of Japan Nuclear Fuel Ltd. for disposal. Concerning other LLW from power reactors which are in storage, relevant safety criteria on disposal are being prepared. Disposal of very low-level concrete waste from dismantling of the Japan Power Demonstration Reactor (JPDR) was completed and the disposal facility was closed in 1997. Reactor of the Tokai Power Station of the Japan Atomic Power Co. ceased operation in 1998 and has been in decommissioning stage since December 2001. The Reactor Regulation Law was amended in May 2005 to provide for clearance, decommissioning application and relevant regulations are established based on IAEA safety standard.[5]

As for the HLW which is generated in the process of reprocessing spent fuel, it was decided to dispose of it in a geological repository after being vitrified and the research and development for that purpose had been conducted mainly by the then Power Reactor and Nuclear Fuel Development Corporation, which was restructured as the Japan Nuclear Cycle Development Institute in October 1998. Based on the results, the Atomic Energy Commission compiled "Basic Concepts for the Disposal of High-Level Radioactive Waste" in May 1998 and the Japan Nuclear Cycle Development Institute compiled "The Second Progress Report on Research and Development for the Geological Disposal" in November 1999. The Government worked to develop a disposal system taking into consideration these policy guidelines and scientific evidence, and enacted the Specified Radioactive Waste Final disposal Act in June 2000. The Nuclear Waste Management Organization of Japan (NUMO) was created in October 2000 as an implementing body for disposal specified in the Act. In December 2002, NUMO started "Open Solicitation", which induced all municipalities to consider the acceptance of investigating the suitability of their local area for developing a deep repository for HLW. Meanwhile, electric utilities and others have been accumulating funds for the disposal of HLW.[6]

Based on the Reactor Regulation Law and/or Electricity Utilities Industry Law, NISA of METI regulates, and issues guidance on facility and activities ensuring the safety of radioactive waste management in repositories, power reactors, uranium enrichment facilities, fuel manufacturing

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3. *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, October 2005, Government of Japan.

4. *Framework for Nuclear Energy Policy*, 11 October 2005, Japan Atomic Energy Commission.

5. *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, October 2005, Government of Japan.

6. *Framework for Nuclear Energy Policy*, 11 October 2005, Japan Atomic Energy Commission.

facilities and reprocessing facilities. Criteria and guidance are established according to the grade of importance of safety to regulate each stage of licensing design, construction, operation and decommissioning, including emergency preparedness.

Based on the Reactor Regulation Law, the STPB of MEXT regulates, and issues guidance on activities to ensure the safety of radioactive waste management in research reactors and fuel material use for research and development purposes, and establishes regulations according to the characteristics and scale of each facility. The STPB, on the basis of the Radiation Hazards Prevention Law, regulates, and issues guidance on activities of radioactive waste management to ensure the safety of facilities using radioisotopes.[7]

Current status of high-level waste management – Basic programme

In line with the Specified Radioactive Waste Final Disposal Act, final disposal facilities are planned for the geological disposal of HLW and are scheduled to start operation in the 2030s through the following three-step selection process:

- selection of preliminary investigation areas;
- selection of detailed investigation areas; and
- selection of the site for repository construction.

When local governments wish to volunteer for "areas to be investigated as to the feasibility of constructing final repository of HLW" (of the Nuclear Waste Management Organization of Japan – NUMO), it is important to foster sufficient understanding and awareness by the local residents about the advantages and disadvantages for the local community to the acceptance and the importance of construction of the final repository. To this end, not only the implementing body, namely NUMO, but the Government and electric utilities, under an appropriate separation of roles and partnership, should enhance the ongoing approaches with their creativity and ingenuity in order to gain understanding and cooperation from the electricity consumers who receive the benefit of nuclear power generation, in addition to the local residents and various sectors of the local community throughout the country, including local governments. It is then important to duly implement the responsibility of each party, such as consideration for new approaches, based on the results of these activities.

It is also expected that the Government, research and development institutions and NUMO, while giving due consideration to their own roles and in close partnership, will consistently promote research and development of geological disposal of HLW. It is expected NUMO will safely implement the final disposal project of HLW and will systematically carry out technical development from the viewpoints of improving economy and efficiency of the activities. Research and development institutions, led by the Japan Atomic Energy Agency (JAEA), through utilisation of underground research facilities, should rigorously continue to conduct scientific research on underground geology, basic research and development toward the improvement of reliability of geological disposal technology and safety assessment methods, and research and development for safety regulations.

As for the outcomes of these research and development activities, while referring to knowledge and experience abroad, it is important to develop and maintain the knowledge as an advanced knowledge base that supports final repository projects and safety regulations, as well as to appropriately reflect it in NUMO's final disposal projects. To this end, the Government and research and development institutions should survey the entire issue and co-operate and collaborate to proceed

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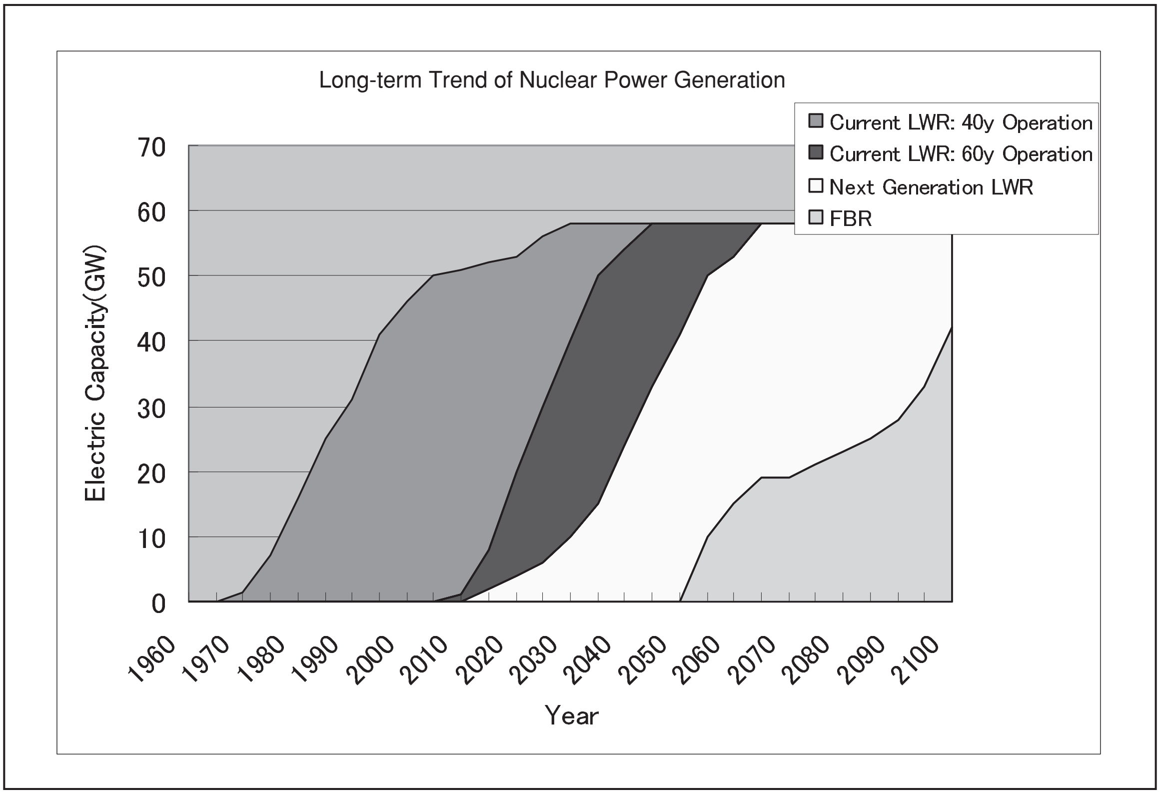
7. *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, October 2005, Government of Japan.

with the programme systematically and efficiently. It is important for research and development institutions to co-operate with the Government and NUMO in activities to gain the understanding and awareness of the people. Furthermore, it is necessary for the Government to develop specific rules concerning safety regulations based on the progress of these research and development activities.[8]

Table 1. Estimation of HLW generation in Japan

		As of the end of 2003	Up to 2048
HLW	Generated in Japan	Liquid HLW: 425 m^3 Vitrified HLW: 130 canisters	Vitrified HLW: 41 000 canisters
	Returned from abroad	Vitrified HLW: 892 canisters	Vitrified HLW: 2 200 canisters

Figure 1. Long-term trend of nuclear power generation in Japan



8. *Framework for Nuclear Energy Policy*, 11 October 2005, Japan Atomic Energy Commission.

Figure 2. Stepwise approach for the disposal of HLW in Japan*

	Literature survey
Following years	Selection of preliminary investigation areas
▼	**Borehole programmes, etc.**
2008~2012	Selection of areas for detailed investigation
▼	**Test programmes in underground exploration facilities**
2023~2027	Selection of the site for repository construction
▼	
Around 2025	Design of the repository and licensing by the government; start of construction
▼	
2033~2037	Start of operation

* (http://www.numo.or.jp/english/jigyou/new_eng_tab03.html)

REPUBLIC OF KOREA

National radioactive waste management policy and principles

The Atomic Energy Commission (AEC) of the Korean government developed the "National Radioactive Waste Management Policy" at the 249th meeting held on 30 September 1998. The policy stipulates that site selection process for radioactive waste repository shall be managed transparently, and the government shall explain to public about its will for securing for safety during site selection process. The summary of the national policy statements includes the following:

- Direct control by the government: Radioactive waste, which needs long-term safe management, shall be managed under the responsibility of government.
- Top priority under safety: Radioactive waste shall be safely managed in due consideration of biological and environmental impact so as to protect the individuals, society and the environment from the harmful effects of radiation and to observe international norms on the safety of radioactive waste management.
- Minimisation of radioactive waste generation: Radioactive waste generation shall be minimised.
- "Polluter pays" principle: the expenses related to radioactive waste management shall be levied on the radioactive waste generator at point radioactive waste generation, without imposing undue burden on future generations.
- Transparency of site selection process: Radioactive wastes shall be managed transparently and openly, and the radioactive waste management project shall be promoted with regard to harmony with the local community, and to community development.

Regarding the disposal facility "National Radioactive Waste Management Policy" decided at the 249th AEC (30 September 1998) was changed through the 253rd AEC held on 17 December 2004. The construction and operation of the LILW disposal facility shall be initiated first to secure the LILW disposal facility at the appropriate time. It includes the democratic and transparent site selection process and the enactment of the local community support. The summaries of the new policy are as follows:

- The LILW should be stored at the existing radioactive waste storage facilities on NPP sites or at the RI storage facilities at first, and then shall be disposed of in either near surface repository or rock cavern repository. The construction shall be accomplished by 2008.
- The national policy for spent fuel management will be decided at a later date through public communication process for national consensus, with consideration given to the domestic and international technology development.

Generals for implementation

Organisations in charge

As a pertinent ministry for the safe and effective management of radioactive waste, the Ministry of Commerce, Industry and Energy (MOCIE) has the responsibility of establishing basic policies and project implementation plans for the storage, treatment and disposal of radioactive waste. These policies and plans shall be implemented by MOCIE under the review and approval of AEC.

The minister of MOCIE will appoint either NPP operator or nuclear related organisation established by special law, to perform the storage, treatment, and disposal activities for the radioactive wastes which are above the clearance level from generators of radioactive waste.

Regulations, codes of practice, and standards

The Ministry of Science and Technology (MOST) together with the Korea institute of nuclear safety (KINS) develop regulations and codes of practice needed for the safe management of spent fuel and radioactive waste. Domestic regulations and codes shall be consistent with international norms including relevant safety fundamentals, safety principles, and safety guides provided by the IAEA.

Interim storage for spent fuel

Spent fuel generated in NPPs has been stored within each plant expanding the storage capacity. With the consideration of the sufficiency of spent fuel storage capacity beyond 2016, the national policy for spent fuel management including the construction of the interim storage facility for spent fuel shall be decided in a timely manner through national consensus by public consultation among stakeholders.

Radioactive waste repository

The LILW generated from NPPs have been stored in the temporary storage facilities within the site of plants until the permanent disposal facility is constructed. The RI wastes from industries, research facilities, medical industries etc., have been stored in the NETEC storage facility. A near surface repository (including rock cavern type) for the LILW shall be constructed by the year of 2008. Initially, the facility will be constructed with a capacity of 100 000 drums on the basis of 200L drum, and an expansion will be considered based on demand (total estimated capacity: 800 000 drums).

Radioactive waste management fund

In accordance with the Electricity Business Act, the NPP operators should bear the cost to dispose radioactive waste generated from its facilities and non-NPP operators should pay for their radioactive waste when they deliver the waste to the nuclear waste management business operator. In this regard, the NPP operators should appropriate the post-NPP disposal reserve and non-NPP operators are recommended to accumulate disposal expenses as well.

Stakeholders' involvement

To promote residents' acceptance, the Korean government has promulgated a "Special Act on Supporting the local county around LILW disposal facility" on 31 March 2005. As for clear and fair process of site selection, site selection committee (SSC), consisting of 17 members, shall manage the overall site selection process. Every aspect of the site selection plan, site investigation result, and site selection process shall be carried out in an openly manner. Finally, site selection shall be done by a local referendum after plenty of explanation to public and discussion among stakeholders.

Status of spent fuel management

Nuclear power plants

Spent fuel discharged from reactors is stored in the spent fuel pool in each reactor unit for certain period, and the on-site storage capacity is expanded. Table 1 represents the location and characteristics of spent fuel storage facilities each plant. As of December 2004, spent fuel inventories for PWRs and PHWRs are 3 397 MTU and 3 889 MTU, respectively. The inventories, initial enrichment of fuel and types of spent fuel in storage are as given in Table 1.

Table 1. Inventory of spent fuel stored in NPPs (as of December 2004)

NPP	Type	Volume stored (MTU)	Initial enrichment (w/o)	Fuel type
Kori site	wet	1 415	3.4~4.2	PWR
Yonggwang site	wet	1 140	3.8~4.4	PWR
Ulchin site	wet	842	3.8~4.4	PWR
Wolsong site	wet and dry	3 889	natural uranium	CANDU

HANARO research reactor

The HANARO is a multi-purposes research reactor with main object of its use for fuel performance testing, material irradiation testing, RI production, basic science and applications study, and is currently in use for various research and development activities.

The spent fuel storage pool of HANARO is a heavy concrete structure, of which the inside is lined with stainless steel plate. The vault comprises three storage lattices. The vault has enough capacity for temporarily storing new fuel as well as spent fuel to be generated during normal operation of HANARO for 20 years. The inventories and types of spent fuel stored at HANARO are as given in Table 2.

Post-irradiation examination facility (PIEF)

The PIEF was constructed for the purpose of performance testing and evaluation for fuels irradiated in NPPs. It is equipped with pool and hot cell facilities to examine irradiated PWR fuel assemblies and fuel rods. Examinations for other types of nuclear fuels PHWR fuel can be conducted in hot cell and pool test facilities whenever deemed to be necessary.

The PIEF consists of 3 pools, 4 concrete hot cells, 2 lead hot cells, and supporting installations. As of December 2004, spent fuels from NPP are stored in the PIEF as form of assemblies, spent fuel rods and specimen in order to carry out the post-irradiation examination. Table 2 represents the detailed status of storage and amount of fissile materials remaining within fuel elements.

Table 2. Inventory of fuels in the storage pool of research facilities

Category of spend fuel		No. of assemblies	^{235}U remained(kg U)
HANARO	36 rod element	156	41.8
	18 rod element	81	11.7
PIEF	PWR assemblies	9	3 192.7
	PWR fuel rods	24	

Radioactive waste management

Nuclear power plants

Nuclear power plants currently in operation are furnished with gaseous, liquid, and solid waste treatment facilities and on-site storage facilities to ensure the safe management of radioactive waste generated in the process of operation. The gaseous waste system comprises gas decay tanks and/or charcoal delay beds. The liquid waste treatment system is equipped with either liquid waste evaporators or selective ion exchangers. The solid waste treatment facility has spent resin drying systems, spent filter processing and packaging systems, concentrated waste drying systems, and super compactors.

The on-site solid radioactive waste storage facility is a concrete slab-type building with separate storage for wastes according to radioactivity level, and is equipped with a radiation monitoring system. As of December 2004, about 62 000 drums of radioactive waste generated from NPPs are stored at the on-site storage facilities. The disposal of radioactive waste has not been implemented yet. Table 3 shows the inventor status of radioactive waste stored at the on-site storage facility.

Table 3. Inventory of radioactive wastes stored in NPPs (as of December 2004)

Facility	Volume [200L drum]	Major radionuclides	Total activity [TBq]
Kori site	32 699	^{60}Co, ^{137}Cs	4,21E+02
Wolsong Site	4 683	^{60}Co, ^{137}Cs	8,14E+01
Yonggwang Site	12 826	^{60}Co, ^{137}Cs	1,13E+02
Ulchin site	12 260	^{60}Co, ^{137}Cs	3,10E+02

Research facilities

The KAERI operates a radioactive waste treatment and storage facility for the safe management of liquid and solid radioactive waste generated from research facilities.

All liquid radioactive waste from the KAERI is processed through an evaporation process followed by additional solar evaporation. The liquid concentrate is solidified by bituminisation process, and stored in the storage facility. Solid waste is treated for volume reduction with a compactor before storage in the storage facility. This facility is divided into 2 storage units for LILW.

The radioactive waste generated from KRR-1 and 2 in the former site of the KAERI in Gongneung-Dong, Seoul were solidified in cement and packaged in 200L drums. They were moved to the KAERI in Daejeon in 1985. Since then, these drums have been stored at the radioactive waste storage facility. Table 4 represents the inventory status of radioactive waste in storage together with major radionuclides as of December 2004.

Table 4. Inventory of radioactive waste stored in the KAERI (as of December 2004)

Facility	Volume [drum]		Major radioactive	Total activity [TBq]
Radwaste storage building	200 L	10 973	^{54}Mn, ^{60}Co, ^{238}U, ^{137}Cs, ^{131}I, etc.	1,2
	50 L	115		

Nuclear fuel fabrication facility

Two nuclear fuel fabrication facilities are now in operation; the 1st plant was constructed in 1988 for PWR fuels and 2nd plant for PHWR/PWR fuels started its commercial operation in 1998. The solid waste treatment and storage concept for the 1st and 2nd plant are almost the same. As of December 2004, the amount of waste generated from the nuclear fuel fabrication facilities is up to 5 310 drums. All of them are stored and managed safely at the on-site waste storage facility. Table 5 shows the inventory of radioactive waste stored at the on-site storage facilities.

Table 5. Inventory of radioactive waste stored at the KNFC facility (as of December 2004)

Facility	Volume [200L drum]	Major radionuclides	Total activity [TBq]
Radwaste storage building	5 310	^{234}U, ^{235}U, ^{238}U	2,8E-01

Radioisotope waste storage

The RI waste generated from domestic RI users is collected and stored the RI waste storage facility. This facility stores 5 155 drums of RI waste as of December 2004 and operates incinerator to treat combustible waste. Table 6 shows the inventory status of RI waste stored in the RI waste storage facility, as of December 2004.

Table 6. Inventory of RI waste in the RI waste storage facility (as of December 2004)

Facility	Volume [200L drum]	Major radionuclides	Total activity [TBq]
RI waste storage facility	4 963 (unsealed source waste	^{125}I, ^{99m}Tc, etc.	1,7E+02
	192 (disused sealed source waste)	^{60}Co, ^{137}Cs, ^{241}Am, etc.	

Decommissioning of KRR-1 and 2

Radioactive waste from the decommissioning of KRR-1 and 2 are safely stored in the on-site interim storage area, classifying with its characteristics and radioactivity level. Minimisation of waste generation has been an important principle for the whole stage of decommissioning. Therefore, new technologies for decontamination have been employed with wider application for decontamination activities of equipments.

The inventory of radioactive waste generated from KRR-1 and 2 decommissioning activities are given in Table 7. In general, most of waste contaminated with ^{60}Co and ^{137}Cs, except for the small volume of waste activated by neutrons.

Table 7. Radioactive waste stored at the KRR-1 and 2 decommissioning activities

Facility	Volume [200L drum]	Major radionuclides	Total activity [MBq]
KRR-1,2 interim storage building	40	^{60}Co, ^{137}Cs, etc.	1,4E+02

Appendix 5
COUNTRY RESPONSES TO ADDITIONAL QUESTIONS ON HLW DISPOSAL PROGRAMMES AND EXPERIENCES IN IMPLEMENTATION

Question	Country	Answer
1a) When did you start your first programme to establish a repository for HLW?	Belgium	1974.
	Czech Republic	Beginning of 90s.
	France	1991 law on waste was the guideline for programmes up until 2006.
	Germany	In the 60s. The legal process for implementation of Gorleben in 1977.
	Japan	60s: Start of discussion, AEC's Committee published a report which includes the discussion on the basic concept. 70s: The basic concept of the disposal was clarified. The fundamental process to the disposal was set. The R&D on the disposal started. 80s: *In situ* experiment. Discussion on the process by the four steps and establishing the implementer. 90s: Broad discussion at the AEC's Committee for the smooth implementation of disposal. The AEC compiled "Basic Concepts for the Disposal of High-Level Radioactive Waste". 1998: JNC compiled "The Second Progress Report on Research and Development for the Geological Disposal", ('99). 2000: Specified Radioactive Waste Final Disposal Act was enacted. In 2002 NUMO was created and started "Open Solicitation".
1b) When do you now expect to start construction?	Belgium	2025.
	Czech Republic	2030 (deep) – 2050 (surface).
	France	The 2006 law states the year 2015 for a "request to proceed on construction" to be placed: It sets 2015 as the deadline to submit the statutory application for the commissioning of a deep geological and reversible repository for high-level and long-lived radioactive waste by 2025.
	Germany	Starting from 2025.
	Japan	Around 2025.
1c) When do you expect to have the facility in operation?	Belgium	2040 for historical waste, non heat-emitting. 2080 for heat-emitting waste (i.e. after a cooling term of 60 years).
	Czech Republic	From 2065.
	France	Commissioning of the facility in 2025.
	Germany	From 2030.
	Japan	2033~2037.

Question	Country	Answer
1d) What issues have taken the time to up to now?	Belgium	R&D programme for clay disposal system started in 1974; URL established in early 1980s; R&D, 1990-2000 results published as SAFIR-2 report; NEA peer review of SAFIR-2 published in 2003.
	Czech Republic	6 sites selected in 2003; phase I site characterisation completed in 2005; government decree suspended work (public acceptance issue) until 2009.
	France	1994: Selection of 3 candidate sites for a potential URL in the Gard, Meuse/Haute-Marne and Vienne Departments; 1999: Authorisation for the construction of an URL in the Meuse/Haute-Marne region. Also a decree requiring the reversibility of the future deep geological disposal and a recommendation that research should also continue on a disposal in a granite formation; 2000: Start of construction of the URL in the Meuse/Haute-Marne region (Bure village) and beginning of the experiments; 2005: Presentation of the results of the research to the Parliament.
	Germany	1963: recommendation of salt formations for host rock; 1965-79: research in salt URL (Gorleben); 1977: application to initiate licensing process; 1974-79: introduction of the Integrated Waste Management concept; 1982: safety criteria for repositories; 1982: decision for 2 repositories, HLW and non-heat generating wastes; 1998: government moratorium on investigations at Gorleben; 1998: new requirement to investigate granite and argillaceous formations; 1999: new committee AkEnd; 2000: AkEnd concept – research of all host rock types, underground exploration is expected to start in 2010; 2002: AkEnd recommend procedure.
	Japan	Establishing the institutional framework; Establishing a decision-making process; Setting-up an implementation organisation (NUMO); R&D on suitable systems and host formations and compilation of the progress reports.
1e) What issues are expected to take the required time in the future?	Belgium	In accordance with the conclusions of the international peer review under NEA auspices of the SAFIR 2 report issued in 2003, and following an official request from the ONDRAF supervising authorities, it was decided to launch, in parallel with the continuation/completion of the R&D and demonstration activities, a societal dialogue in view of confirming the disposal in Boom clay as the reference solution for the long-term management of HLW/MLW in Belgium. This will be done through a Waste Plan that will include SEA (comparison of alternatives and environmental impact assessment).
	Czech Republic	2015: to select sites with proper geological conditions taking into account local developments at proposed sites. After evaluation of relevant results include two sites into land use plans (main and reserve one) for deep geological repository; 2025: on the basis of geological work performed and complex data analysis confirm the suitability of one site for a geological repository; 2030-2060: to prepare the necessary documentation for construction of an URL and performance of long-term experiments for confirmation of safety of deep geological repository.
	France	Public debate likely to be held in 2012-2013; submission of statutory application in 2015; construction of facility between 2015-2025; commissioning in 2025.
	Germany	Regulations for site selection and safety requirements; Nomination of further candidate sites besides Gorleben; Site investigation; Final decision on the site.
	Japan	The following three-step selection process is stipulated by the Specified Radioactive Waste Final Disposal Act: • selection of preliminary investigation areas; • selection of detailed investigation areas; and • selection of the final disposal facility areas.

Question	Country	Answer
2) Most countries now recognise that there is a requirement for the local host community to be willing to accept a repository for the implementation programme to be successful. What arrangements are there for the host community to benefit from the repository in your country (e.g. construction of new facilities which will benefit them, reduction of local taxes, etc.)?	Belgium	No specific measures. Local acceptance and participation in the project development are indeed of high importance, as demonstrated by the successful "partnership" approach for the LLW disposal project in Dessel. As no siting decision has yet taken place, arrangements with host community (ies) have not yet been discussed.
	Czech Republic	Currently there are no arrangements effective.
	France	The 2006 Planning Act defined the: • Local Information and Follow-up Committee (CLIS): among the functions of the new CLIS (expected by the end of 2007) there is a concertation mission concerning research on the management of radioactive waste, and especially on deep geological disposal; • High Committee for Transparency and Information on Nuclear Safety; • Nuclear industry involved in local development; • In addition to the direct benefit from the economic advantage of the facility itself the Public Interest Group (GIP) is being formed in charge of the economic development of territories 20 million euros/Département/year; resources are allocated, in priority, to a proximity area that is defined by the 2006 Planning Act.
	Germany	No specific measures. AkEnd recommendation: "The potential site regions are to be offered a plan for a regional development perspective and government support in its implementation. This may not solve the conflict between the national task of establishing a repository for radioactive waste and the regional interests, but it may after all build a bridge between national and regional interests. The Committee suggests this form of perspective instead of short-term financial compensation. However, the funding for the long-term implementation of development perspectives must be secured."
	Japan	No specific measures, but see the following quote: "…When local governments wish to volunteer for "areas to be investigated as to the feasibility of constructing final repository of HLW", it is important to foster sufficient understanding and awareness by the local residents about the advantages and disadvantages for the local community to the acceptance and the importance of construction of the final repository. Not only the implementing body, NUMO, but the Government and electric utilities, under an appropriate separation of roles and partnership, should enhance the ongoing approaches with their creativity and ingenuity in order to gain understanding and cooperation from the electricity consumers who receive the benefit of nuclear power generation, in addition to the local residents and various sectors of the local community throughout the country, including local governments. It is then important to duly implement the responsibility of each party, such as consideration for new approaches, based on the results of these activities. Grant – in-aid to the potential local governments…"[1]

1. *Framework for Nuclear Energy Policy*, 11 October 2005, Japan Atomic Energy Commission.

Question	Country	Answer
3) Do you have any surveys or data on what issues are of most concern to the potential host communities?	Belgium	Belgium has already gained a relative large experience in dialogue with local communities. Safety, environment, health are the priority concerns, while local development is a concern for the host communities.
	Czech Republic	Currently underway at all six candidate sites and on one reference site. Results will be available in the second half of 2007.
	France	–
	Germany	Recent publication: Peter Hocke; Armin Grunwald (Hg.) (2006), *Wohin mit dem radioaktiven Abfall?: Perspektiven für eine ozialwissenschaftliche Endlagerforschung*. Berlin: Ed. Sigma. Issues are: • doubts in the safety and lacking confidence and assured safety standards as well as corresponding surveillance • fear of “radioactive” (ionising) radiation; • fear of a creeping long-term contamination of the groundwater by radioactive substances and further contaminations of the biosphere; • fear of an impairment of the home region’s reputation from the stigmatisation as “repository region” with corresponding consequences for the local economy, the attractiveness for investors or tourism; • fear of a “debasement” of the own region, for instance by a decrease of the real estate prices; • fear of a loss of the region’s identity by the settlement of a large-scale industrial repository plant and its additional facilities and also for a drastic increase of hazardous material transports via rail and road.
	Japan	Group interviews: In 2002, NUMO conducted 13 group interviews in order to better understand public interest and concerns related to deep geological disposal. A total of 78 people, randomly selected from a list of a Tokyo-based public survey firm, contributed to the interviews. Following five aspects emerged as general characteristics: 1) Most people have no concrete image of what HLW actually is. 2) Many people would like to know how issues associated with HLW disposal were perceived socially at the beginning of development of the nuclear power programme. 3) Instead of being concerned about long-term safety, people tend to worry more about risks in the immediate future, such as operation of reprocessing plants and transportation of HLW. 4) Some people expect major future developments in science and technology, so they do not recognise geological disposal as being a “favorable” strategy at present. 5) The NIMBY syndrome clearly exists in the case of the HLW repository siting.[2]

2. S. Inatsugu, M. Takeuchi, T. Kato (2006), *Public Perspectives in the Japanese HLW Disposal Program*. Paper presented on the VALDOR 2006, NUMO, Sweden.

Question	Country	Answer
4) Have you used any formalised decision-making process (for example multi-criteria decision analysis) in choosing: a) The site for the repository?	Belgium	No. The technical suitability of the underground Boom Clay layer in the Mol region was investigated for the possible safe disposal of all HLW/MLW produced in Belgium. In function of the positive results of those investigations, the Boom clay layer in Mol was considered as the reference disposal solution for Belgium. This does not however prejudge the decision to construct a geological repository in this place, before which a complete licensing process must be conducted, in line with the national and international regulations. As far as national regulations are concerned, specific provisions do not exist yet in the legislation concerning the decision-making process for HLW/MLW disposal. The regulatory authorities are currently developing such a decision-making process.
	Czech Republic	Multi-criteria decision analysis will be prepared for the next phase.
	France	Scientific expertise was involved in the process of site selection. This helped go from numerous sites initially to 4 in the 1990s, to 3 in 1994, to 1 in 1999 (current location of the URL). Obviously other issues were also taken into account.
	Germany	The existing legal framework for the site selection is currently under revision by the Federal Government.
	Japan	The following three-step selection process is stipulated by the Specified Radioactive Waste Final Disposal Act: • selection of preliminary investigation areas; • selection of detailed investigation areas; and • selection of the final disposal facility areas.
b) The timing for the start of construction or the timing for the opening date?	Belgium	The provisional timing for starting the construction and operation of the repository given in the report is governed by the willingness to dispose of the waste as soon as possible, based on the present Belgian nuclear programme.
	Czech Republic	As for 4a).
	France	Decision making for the site selection has been well described and followed in the 1991 law on radioactive waste. Timing of future decisions (leading up to construction and commissioning of the facility) is described in the new 2006 law.
	Germany	As for 4a).
	Japan	As for 4a).
5) If you have used formalised decision-making techniques, can you please provide some information on what they were and how they were used?	Belgium	Currently under development.
	Czech Republic	Will be prepared for the next phase.
	France	Formalised decision-making techniques, such as multi-criteria decision analysis, are used in the concept selection process. Site selection is a more complex process.
	Germany	Currently under revision.
	Japan	–

OECD PUBLICATIONS, 2, rue André-Pascal, 75775 PARIS CEDEX 16
PRINTED IN FRANCE
(66 2008 02 1 P) ISBN 978-92-64-04625-2– No. 56185 2008

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This study identifies key factors influencing the timing of high-level waste (HLW) disposal and examines how social acceptability, technical soundness, environmental responsibility and economic feasibility impact on national strategies for HLW management and disposal. Based on case study analyses, it also presents the strategic approaches adopted in a number of national policies to address public concerns and civil society requirements regarding long-term stewardship of high-level radioactive waste.

The findings and conclusions of the study confirm the importance of informing all stakeholders and involving them in the decision-making process in order to implement HLW disposal strategies successfully. This study will be of considerable interest to nuclear energy policy makers and analysts as well as to experts in the area of radioactive waste management and disposal.

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(66 2008 02 1 P) € 45
ISBN 978-92-64-04625-2

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