Current policy and research on radioactive waste management in the European Union

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Abstract

Each Member State of the European Union is responsible for the safe management and disposal of the radioactive waste produced on its own territory. This includes setting the policy and taking the necessary steps to assure that the radioactive waste does not constitute a threat to the health of workers and the general public. For the practical implementation specific waste management organisations have been established. An extensive co-operation, not least in the area of research, is taking place between these organisations and between the regulatory authorities, both bilaterally and through the European Commission.

Co-operation takes place at the level of the European Commission by two different mechanisms, the Community Plan of Action in the field of radioactive waste and the EURATOM framework programme on research and training. In view of the future enlargement of the European Union the Commission is also actively involved in the development of waste management practices in the Central and Eastern European Countries. Waste management is also an important aspect of the Tacis and other nuclear safety support programmes to the States of the former Soviet Union.

The general policies for waste management are in all Member States in harmony with the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management. The specific policies are, however, dependent on the specific conditions of that state, e.g. the existence, size and time perspective of the nuclear power programme, the geological formations available for disposal (clay, salt, crystalline rock) etc.

The management of short-lived waste is an established practice in many Member States and the research needs are consequently low. Most of the policy efforts and research is thus dedicated to the management, treatment, conditioning and geological disposal of long lived waste and spent fuel. Each Member State with a nuclear power programme also has an important research programme. The use of underground research laboratories is very important in this context. They also provide the platform for an extensive international co-operation.

In addition to having suitable geological conditions it is also necessary that a site for a repository is accepted by the population from a socio-economic point of view. An important tool for evaluating the technical/scientific safety as well as the socio-economic acceptability is the Environmental Impact Assessment (EIA). Under EU law, an EIA is compulsory for a waste disposal facility as well as for other nuclear facilities. The EIA should ensure transparency in the decision making and provides the necessary involvement of the public in the decision process.

Introduction

Nuclear energy provides more than 35 % of the electricity generated in the European Union. It makes a significant contribution to the policy of diversifying energy supply and to reducing overall emissions of CO_2. Eight of the fifteen Member States have nuclear power plants in operation with a total installed capacity of about 126 GW_e. Annually about 50 000 m^3 of conditioned radioactive waste is generated. Radioactive waste is generated in all Member States, even if the quantities of waste needing long-term storage and disposal are very small in the countries without nuclear energy production capacity. The waste comes mainly from four types of activity; nuclear electricity generation, including back-end fuel cycle activities and decommissioning, the operation of research reactors, the use of radiation and radioactive material in medicine, agriculture, industry and research, and the processing of material containing natural radionuclides.

The safe and long term management of radioactive waste is by many, not least in the general public, seen as the "Achilles heel" of nuclear power, and a major impediment to future use of nuclear energy. Transports of spent fuel and radioactive waste and siting activities for waste management facilities have raised a lot of public concern and in some cases large manifestations. The subject is thus highly political, and the Governments and Parliaments are strongly involved in setting the policies for radioactive waste management.

The radioactive waste is classified according to the need for long-term isolation. Three categories can be distinguished; short lived low and intermediate level waste that can be disposed of in surface or near surface repositories, long lived low and intermediate level waste that needs to be disposed of in deep geological formations, and high level waste and spent fuel for which the heat generation must also be taken into account.

Short lived low and intermediate level is already conditioned and disposed of in several Member States and the need for research in this area is limited. In other Member States siting activities for a repository are in progress, or the waste is only stored for the time being. The latter is the case for those Member States that don't have a nuclear power programme and thus only small quantities of radioactive waste.

The annual amount of fuel used in the European Union is about 3000 tonnes of uranium. Different policies for the handling of the spent fuel are adopted in the Member States. Some favour reprocessing of the fuel in order to better utilise the energy content (by recycling of the plutonium) and to reduce the volume of high level waste to be disposed of. Others regard the spent fuel as a waste and plan to dispose of it in a deep geological repository. Recently there has also been a renewed interest in studying advanced reprocessing, partitioning and transmutation to further reduce the amount of long-lived radionuclides that needs to be disposed of.

In this paper an overview will be given of the policies adopted for radioactive waste management in the European Union and the Member States and of the research and other activities undertaken to close the remaining issues.

Responsibilities – The role of the European Commission

Each Member State of the European Union is responsible for the safe management and disposal of the radioactive waste produced on its territory. This includes setting the policy and taking the necessary steps to assure that the radioactive waste does not constitute a threat to the health of workers and the general public in accordance with the European directive on Basic Safety Standards /1/.

An extensive co-operation exists between the Member States, both bilaterally and within the framework of the European Union. The co-operation covers policy as well as research. In 1973 the Community Environmental Programme was approved which underline the need for Community measures covering the "particular case of the handling and storage of radioactive waste". In 1975 a programme for research on the management and storage of radioactive waste was adopted as part of the Community's research activities, and in 1980 a Community plan of action in the field of radioactive waste was adopted. Both the research programme and the plan of action have been renewed at regular intervals.

The Plan of Action requires the Commission to "periodically provide the Council with an analysis of the situation and prospects for radioactive waste management in Member States, with special reference to safety and environmental protection requirements and the requirements of nuclear programmes and activities involving radioisotopes". The latest "situation report" was published in January 1999 /2/.

The Plan also calls for:

- Technical co-operation to develop a common approach and work towards harmonisation at Community level on radioactive waste management strategies and practices wherever possible
- Approximation of national practices and regulations in the field of safety of disposal and the drawing up of recommendations regarding safety assessment in the storage of radioactive waste and to establish relevant criteria.
- Intensify efforts to provide the public with regular information on their activities in the field of radioactive waste management.

In the Plan of Action, the Council stressed the importance of developing "co-operation between the Community and third countries, in particular those of central and eastern Europe including the republics of the former Soviet Union, in the management and storage of radioactive waste taking into account the new challenges likely to arise following the future dismantling of several plants using outdated technology". In view of the planned enlargement of the European Union, which involves several states with an important nuclear power programme, these challenges are becoming even more important. Over the last eight years the European Union has financed studies and safety improvements in the applicant countries.

Facilities for the storage and disposal of radioactive waste and spent fuel must, under European law, be the subject of an Environmental Impact Assessment (EIA). We will return to this later.

Further there is an EU Directive covering shipments of Radioactive Waste between Member States and into and out of the Community. This will be described in another paper of this Conference.

Country	Radioactive Waste Management Agency	Status
Belgium	ONDRAF/NIRAS	Public
Finland	POSIVA	Producer owned
France	ANDRA	Public
Germany	BfS	Federal body
Italy	NUCLECO	Semi-public
The Netherlands	COVRA	Producer owned
Spain	ENRESA	Public
Sweden	SKB	Producer owned
United Kingdom	BNFL and UKAEA for local disposal NIREX	Producer owned

Table 1 Waste management agencies in the EU Member States with a nuclear power programme

Waste management policies and organisation

The general policies for waste management are in all Member States in harmony with the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, which has been signed by most of the Member States. The specific policies are, however, dependent on the specific conditions of that state, e.g. the existence, size and time perspective of the nuclear power programme, the geological formations available (clay, salt, crystalline rock) etc. Nevertheless a number of common features exist. The waste producer is for example responsible for the financing and specific financing rules are established. Low- and intermediate level short lived waste is conditioned and disposed of shortly after they are produced in most Member States. Spent fuel and/or high level and long lived waste is planned to be disposed of at depth in geological formations, after a certain period of interim storage. The foreseen length of this period, however, differs, and is in some Member States subject to special studies.

Organisation

Each Member State has clearly identified the bodies responsible for the radioactive waste management in the country. For the countries with a nuclear power programme separate waste management agencies have been created to take care of the waste at a certain point in the process and dispose of it. The responsibility of the agency includes in some countries all steps from interim storage and transport to disposal, while in other countries the waste producers are themselves responsible for the first steps. A list of the relevant waste management agencies is given in Table 1. In half of the countries the responsibility for disposal is taken by the state and the agency is thus a public organisation. In the other half the large waste producers are responsible for disposal and thus owns and operates the waste management agency. In all cases the costs for their activities are covered by the waste producers.

In the countries without a nuclear power programme the waste is normally taken care of and stored at a dedicated research facility.

Country	Facility	Type	Status
Finland	VLJ, Olkiluoto LOSI, Loviisa	Rock caverns at 50 – 100 m depth	Operating Operating
France	Centre de la Manche Centre de l'Aube	Surface engineered Surface engineered	Closed Operating
Germany	Asse Morsleben Konrad	Deep salt test facility Deep salt caverns Deep iron mine	Closed Closed Licensing
Spain	El Cabril	Surface engineered	Operating
Sweden	SFR, Forsmark	Rock caverns at 50 m depth	Operating
United Kingdom	Drigg Dounreay	Surface Surface	Operating Operating

Table 2 Facilities for disposal of short lived low and intermediate level waste in the EU Member States

Financing

The costs for management and disposal of the waste from nuclear power production and research centres are borne by the waste producer. Different financing schemes have been set up in the different countries, but with the common purpose to internalise the costs in the power production/research. In some countries a fee is levied on the power production and collected in segregated funds. In other countries the costs are treated as future liabilities in the balance sheet. The cost for waste from small producers is normally covered by a fee when the waste is taken care of /3/.

Waste management programs and plans

Short lived low and intermediate level waste

Disposal of short lived low and intermediate level waste is practised since many years in most of the Member States with a nuclear power programme (see Table 2). Engineered surface facilities are in operation in France, Spain and the United Kingdom, while facilities at 50 – 100 m depth in rock caverns are in operation in Finland and Sweden. Disposal facilities at greater depth have been operating in Germany and the licensing procedure is in an advance stage for a new repository in the former Konrad iron ore mine. In Belgium the site selection process is going on for an engineered surface facility. This is also the case for Italy, but with less intensity. The Netherlands is planning to store its waste for about 100 years.

Long-lived low and intermediate level waste

The needs for isolation for long lived low and intermediate level wastes are similar to those of high level waste and spent fuel. These wastes will thus also be disposed of at depth in a geologic repository, and the planning for the development of repositories are in many countries performed in parallel. In some Member States separate projects are developed due to the larger volumes of these wastes, in particular for countries reprocessing their fuel. This is the case in Germany, where long lived wastes with negligible heat generation are planned

to be disposed of in Konrad (see above), and the UK, where investigations were carried out for a separate facility for long lived low and intermediate level waste at Sellafield. The work at Sellafield has, however, been terminated after the refusal of the Government in 1997 to permit the construction of an underground "Rock Characterisation Facility". The planning of future activities on disposal of long lived low and intermediate level waste will be part of a total review of the policy for long-lived radioactive waste, which was announced by the British Government in October 1999 /4/.

High level waste and spent fuel

There is no common policy in the European Union on whether the spent fuel shall be reprocessed or not. Different approaches are made by different Member States and the approaches have also changed over time. Irrespective of which route that is chosen a long-lived waste product will have to be taken care of for further treatment, conditioning and disposal, be it spent fuel or high level vitrified waste. Until about ten years ago practically all efforts were dedicated to studies of geological disposal. More recently, however, there has been a renewed interest in some Member States to explore alternative routes, e.g. partitioning and transmutation to reduce the toxic life length of the waste or long term controlled storage. The purpose of these studies is to provide a better knowledge base when the decisions on the preferred strategy will be made.

Geological disposal have been the preferred option for management of high level waste and spent fuel since the 1960's and it is recognised that even if transmutation can reduce the life length it will not totally remove the need for geological disposal. The available geological formations are, however, differing between the Member States. In Germany and the Netherlands salt domes have been the main formations of interest, while in Finland and Sweden the studies have been concentrated on crystalline rock, and in Belgium and Italy on soft clay. France, Spain and the United Kingdom have studied several available media. Already in 1980 the European Commission published a catalogue of suitable geological formations in the Member States. This report was prepared by the National Geological Institutes.

The planning schedule for decisions on and implementation of disposal facilities is quite advanced in some Member States, while others foresee at least a 50 years interim storage period for the waste. A crucial stage in the time schedule is the site selection process. Germany made an early decision to concentrate the efforts on investigating the Gorleben salt dome. Finland has recently concentrated their efforts to Olkiluoto and the process for a decision in principle is well advanced. In France decisions to build a first underground laboratory were taken in 1998/1999. A site for a second laboratory will also be sought. If the conditions are suitable it is foreseen that a repository could be built in the immediate vicinity of the laboratory. At the other end of the scale The Netherlands has decided on an interim storage period of 100 years and is thus not looking for a disposal site now.

An overview of the plans for the Member States with a nuclear power programme is given in Table 3, and some more details in Annex 1. A common feature of most plans is the step-wise approach to a decision on the final strategy for management of the high level waste and spent fuel. This includes geological investigations for siting, and technical studies of alternative management routes, but also advanced discussions about how to broaden the basis for decision-making and how to involve the interested public in this work. It has become clear that ample time must be allowed for this process.

Country	
Belgium	At least 50 years interim storage. Investigations in Boom clay at Mol-Dessel. HADES underground research laboratory.
Finland	Site selection in progress, Olkiluoto preferred site. Decision in Principle expected soon. Construction of repository to start in 2010.
France	Law of 1991 defines research in parallel on partitioning and transmutation, disposal and long term storage. Authorisation given for two underground laboratories to make geological site investigations for a repository.
Germany	Extensive investigations of the salt dome in Gorleben. Shafts and exploration galleries built. At present work suspended pending a re-examination of siting criteria. Repository in operation 2030.
Spain	R&D to continue but at a lower pace, and with no further geological investigations. R&D on partitioning and transmutation. No decision on the final strategy will be made until 2010.
Sweden	Site selection in progress. Technical, geological and socio-economic studies are performed in 6 municipalities. At least two sites will be selected in 2001 for geological investigations. Step-wise decision process, including step-wise construction of the repository.
United Kingdom	Revision of the policy for long term management of radioactive waste initiated. Recommendations by a House of Lords Select Committee
Italy, Netherlands	Policy is deep disposal after 50 – 100 years storage.

Table 3 Overview of plans for management of high level waste and spent fuel in the EU Member States

In the UK, for instance a widespread consultation on the best way to manage radioactive waste will start in 2000, with the intent to develop a policy in the most transparent and open-minded way to ensure maximum public acceptance. In Germany the siting criteria are being reconsidered. In France and Spain dates have been set to make the decisions in 5 – 10 years time with clear demands on the information that should be available then. In Finland and Sweden the step-wise decision process and environmental impact assessment will provide for wide consultation of the public. In most countries the issues of retrievability have become important.

Research programmes

Intensive research and development programmes have been running since the 1970's in all Member States with a nuclear power programme. In 1975 the European Commission started its first co-operative programme, which involved the laboratories and organisations in the Member States, through "shared cost" actions.

In the early programmes substantial efforts were directed towards the treatment and conditioning of different types of waste, in particular low- and intermediate level waste, and

also on disposal of these wastes. As these techniques have been commercially established and put in practical use the R&D in this area has diminished.

For long-lived radioactive waste the disposal in deep geological formations has been the main management alternative in all Member States and the research efforts have thus primarily been dedicated to this task. During the last ten years there has been a renewed interest in the possibility of reducing the long-lived radioactivity in the waste by partitioning and transmutation (P&T). This interest emanates primarily from the difficulties encountered with the public concerning the very long time scales of geological disposal, but also from positive developments on accelerator technology, and the possibility for a new technology for energy production.

Partitioning and transmutation

France has the largest programme on P&T in Europe, but research is also performed in many of the other Member States. There is a strong co-ordination on the European level, both multi-laterally and through the European Commission. P&T is one of the priority areas in the fifth framework programme, and was also included in the third and fourth programme. The aims of the studies are to investigate the capability of P&T, on an industrial scale, to reduce the amount of long-lived radionuclides to be disposed of.

In partitioning the work includes development of aqueous processes with more selective extractants for separation of the minor actinides and long-lived fission products from the high level waste stream. Also pyrochemical processes are being studied.

For transmutation early work was centred around the use of MOX-fuel in LWR and burning of plutonium, minor actinides and fission products in LWR and fast neutron critical reactors. Over the last years most of the interest has been concentrated on Accelerator Driven Systems, with a sub-critical reactor (metal- or gas-cooled) coupled to an accelerator via a spallation target for neutron production. The research includes basic physics studies as well as the technology needed for constructing a demonstrator. Critical issues are the fuel behaviour, the accelerator stability and the coupling between the accelerator and the sub-critical reactor.

Deep disposal of spent fuel, high level and long-lived wastes

The main strategy in most of the Member States is that the spent fuel or high level waste and other long-lived radioactive wastes (incl. waste from P&T) shall be disposed of in deep geological formations. The design of a repository is based on the principle of multiple H √ barriers, i.e. waste form, waste package, buffer and backfill and the geological environment. The geological formation provides long term stable conditions and is an efficient barrier to transport of the radioactive species from the waste (absolute in the case of salt, and slow and retarded transport in the case of clay and crystalline rock). To get acceptance for a disposal facility you need:

- A site with suitable geological conditions, that is accepted by licensing authorities and the public;
- A technical method for encapsulation, handling and disposal;
- A scientifically based, comprehensive safety assessment for the behaviour of the repository in the short and long term;

The three points are strongly inter-related, and the research efforts must thus be co-ordinated by a total systems analysis. The main players in the European Union are the waste management agencies, who are responsible for the implementation of disposal facilities, and the regulatory authorities (and their Technical Support Organisations). A strong scientific and technical co-operation has been established between the organisations in the Union as well as with the corresponding organisations in other countries. This co-operation includes co-operative research programmes (bilateral and through the EC framework programme), establishment of common positions on critical issues (in co-operation with OECD/NEA and IAEA), exchange of scientists etc.

Selection of a site with suitable geological conditions

As was described earlier site selection activities are in progress in many of the Member States, and important steps have been made over the last few years. The work involves geological investigations as well other socio-economic studies as a basis for the future environmental impact assessment. An important component is the development of methods for making investigations at depth and the tools for interpreting the measurements and incorporating the results into conceptual and mathematical models of the site.

Development of repository systems

Conceptual designs for repositories have been developed in most Member States. The designs are adopted to the geological formation and to the waste products that are foreseen in the specific country. There are fairly large differences in the design for a repository in salt as compared to a repository in crystalline rock or in clay. Recently these designs have been re-considered to investigate the possibilities of an extended period of retrievability.

The repository development work includes techniques for excavation of the disposal areas with minimum disturbance on the surrounding rock, techniques for handling the waste packages and for back filling and sealing the tunnels and deposition holes. Much of this work is done in underground research laboratories. At present the waste management agencies in the Union have development and demonstration projects in the Asse salt mine in Germany, the HADES facility in Boom Clay in Belgium and the Äspö hard rock laboratory in Sweden. Research is also made in the Tournemire research tunnel in hard clay in France. The agencies also participate in the Grimsel and Mt Terri projects in Switzerland, as well as in similar projects in Canada and Japan. Some examples of demonstration experiments are:

- CLIPEX in Hades and ZEDEX in Äspö to study the influence of the excavation on the host medium (excavation damaged zone, EDZ);
- RESEAL in HADES, BAMBUS in Asse, FEBEX in Grimsel and the Prototype repository in Äspö to study the application of back-fill and plugs and to verify their function under real conditions;

An important component of a repository system is the waste container or overpack, which should provide containment and shielding of the waste during handling, and isolation of the radionuclides for a certain period of time after disposal, a thousand years or more. In some Member States full scale facilities have been built to develop the techniques for encapsulation. In the PKA in Gorleben, Germany, spent fuel is planned to be encapsulated in large shielded disposal containers of steel, so called POLLUX containers. In the Canister

Laboratory in Oskarshamn, Sweden, cold tests of sealing and testing of copper canisters for spent fuel will be made.

Safety and performance assessments

The perhaps most challenging task in connection with radioactive waste management is to demonstrate the safety of a repository in the long-term. This can, however, never be demonstrated directly as the time frames considered are too long. The demonstration of the long-term safety will thus always have to rely on calculations and indirect evidence, and be based on the capacity to model the performance of the different barriers.

Comprehensive performance and safety assessments have been made in many of the Member States. The early assessments that were made in the late 1970s and early 1980s were based on rather crude models and with conservative assumptions, where knowledge was missing. These safety assessments have been successively refined to incorporate more detailed models and more reliable data. Examples of recent safety assessments performed or under preparation by the waste management agencies in some Member States are:

- NIREX-97, disposal of long-lived intermediate level waste at Sellafield in the UK /5/,
- TILA-99 and SR-97, disposal of spent fuel in crystalline rock in Finland and Sweden, respectively /6,7/,
- ENRESA-2000, disposal of spent fuel in different geological media in Spain /8/, and
- SAFIR-2, disposal of high-level and long-lived waste in clay in Belgium /9/.

Over the years the European Commission has supported co-ordinated studies on performance and safety assessment. The first large scale performance assessment, PAGIS was conducted in the period 1982 – 88, and was concerned with disposal of high level vitrified waste in four different geological media, salt, clay, crystalline rock and the deep subseabed. This was followed by an assessment for disposal of alpha bearing wastes, PACOMA, and the EVEREST sensitivity study of the consequences of uncertainties. During the last four years the performance assessment for spent fuel disposal has been studied in the SPA project.

In parallel to these studies also the MIRAGE project was conducted (1983 –95), which was a European network on Migration of Radionuclides through the Geosphere. The goal of MIRAGE was to improve the scientific-technical basis for describing the processes and parameters that control the transport and retardation of radionuclides in the geosphere. An important part concerned transport of radionuclides with colloids.

Basic understanding (incl. natural analogues)

To support the safety and performance assessment and the technical implementation studies research is carried out in a number of areas, ranging from basic physics and chemistry of the radionuclides to future climatic variations. In all these areas an extensive international co-operation takes place. Here only one special area will be mentioned, studies of natural analogues, i.e. studies in nature of processes that are relevant for the performance of a repository. In response to the growing interest in natural analogue studies in the Member States and the formation of a number of international co-operative natural analogue projects, the Commission formed in 1985 the “Natural Analogue Working Group”, to improve the co-operation and foster cross fertilisation. The purpose of these studies is to identify processes for transport of radionuclides in the geological environment, to develop and test numerical

models, to provide data/information in support of the performance assessment and to enhance the confidence building and, not least, the public perception. Natural analogues exist for transport processes in sediments and fractured rock, and for behaviour of different material, e.g. clay, bitumen, cement and copper.

Role of underground research laboratories

The development of underground research laboratories has been essential for the development of knowledge for repository systems. They are used for:

- Technical development of the necessary equipment and facilities (as described above);
- Scientific studies to understand, in a real environment, the relevant processes that will affect the safety of the repository;
- Development of methods for investigating the geological media, and
- Demonstration to the interested public what a repository could look like.

The construction of underground research laboratories was considered necessary already at an early stage. In the 1970s research underground was started in the Asse salt mine in Germany and in the Stripa iron ore mine in Sweden. These projects were from the start international projects with participants from several countries. Later new underground research laboratories were built in Belgium (HADES), and Sweden (Äspö). Most of these were "methodological" laboratories that were planned purely for research and not to be transferred into a repository. The next generations of laboratories are "characterisation" laboratories, which are built for the characterisation of the geological environment. If suitable it will then be used as the first part of the repository. This was the intention for the Sellafield Rock Characterisation Facility, and is the intention in Gorleben, Germany and for the planned underground laboratories in France. HADES involves both components.

The framework programme of the European Commission

Research and development in the area of radioactive waste management and disposal has been part of the programme of the European Commission since 1975. Most of the work is performed through "shared cost" actions at laboratories in the Member States with financial support from the Commission (up to 50 % of the costs). Some work in the area is also performed directly by the Commission's Joint Research Centre. Over the last 15 years the financing of shared cost actions from the Commission has been on an average 15 million € per year. Only multinational projects with an added European value are now accepted for financing. In the present 5th framework programme research covers waste and spent fuel management and disposal, partitioning and transmutation and decommissioning. Practically all the key players in the Union, i.e. waste management agencies, authorities and technical support organisations are involved in the projects of the EC programme, thus providing a good platform for co-operative work and information exchange.

Public involvement – Environmental Impact Assessment /10/

Management and disposal of radioactive waste, as indeed the whole nuclear fuel cycle, is a highly political issue that raises a lot of debate and concern among the public. There are many reasons for this, e.g. the invisible danger, the connection to the nuclear weapons, and the inexplicably long time perspectives. One prime reason is also the perceived secrecy of the nuclear industry and the historic legacy of non-communication. A modern society demands

ways, formal and informal, for the public to be involved in complicated decision making. The decision on waste management policy and the siting of waste management facilities is no exception. In many of the EU Member States extensive debates have been held in expert committees and on parliamentary level on the policy for nuclear at large and waste management in particular.

In connection with the siting activities a clear tendency can be seen in most Member States away from the so called decide, announce and defend (DAD) principle to a much more co-operative approach. The latter includes direct co-operation between the waste management agencies and the municipalities concerned. It is, however, not enough to involve the political leaders. Ways of involving the interested public much also be found. In this context siting of waste management facilities can be seen as an experiment in practical democracy. Examples of this approach can be found in Belgium, Finland, France, Spain and Sweden.

Probably the most important tool in the decision process for a waste management facility is the Environmental Impact Assessment (EIA). According to the EU Directives on EIA /11,12/ an EIA is required for all nuclear facilities, including geological repositories. The Directive gives guidance on how an EIA shall be made and what is required of the process. An important part of the process to produce an EIA report is the establishment of the key issues, through consultation of all concerned parties, including the authorities and the public. The EIA should be a joint product of the local community and the waste management agency. Both parties should be able to fully endorse its findings. The EIA process thus provides an excellent tool, if properly used for involvement of the interested public and for a two-way communication.

Conclusions

Radioactive waste management has been an important issue for a long time in all Member States with a nuclear power programme. Research in the area started more than 40 years ago. In the early phase the R&D was primarily focused on the development of suitable processes for treatment and conditioning of the waste. In the early 1970's the work towards disposal of the radioactive waste took on speed. The first priority was to dispose of the large volumes of short-lived low and intermediate level waste, and disposal facilities were subsequently built any many Member States. The disposal of these wastes is an established industrial practice today and about 2 million cubic metres of such waste have already been disposed of

For the spent fuel and high level and other long-lived wastes an interim storage period of several decades have always been planned before disposal. The early phase of basic research and preliminary design for disposal has in some Member States been passed and the emphasis is now on selecting suitable sites for geological repositories. This process is stepwise, with clear periods in between of reflection on the general principles to be followed. A general trend can be seen that a broader basis for decision is required. Alternative management routes are also explored and compared before final decisions are made.

Since the early days there has been a large component of international co-operation, primarily in the field of research. This co-operation is bilateral as well as through the different international organisations. Common views have been developed on the basic principles to be adhered to as well as on the state of knowledge and capabilities. Within the European Union specific co-operation takes place within the Community Plan of Action and the shared cost

research programme. Increased emphasis will be placed on the disposal of spent fuel, high level and other long-lived wastes.

References

/1/ Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards, for the protection of the health of workers and the general public against the dangers arising from ionising radiation (OJ L 159 29.06.96 p. 1)

/2/ Communication and Fourth Report from the Commission on the Present Situation and Prospects for Radioactive Waste Management in the European Union, COM (98) 799 final (January 99)

/3/ Emmery, D., Kunsch, P., Bollingerfehr, W., Webster, S., The Financing of Radioactive Waste Storage and Disposal : Hearsey, C.J., EURADWASTE'99 "Radioactive Waste Management Strategies and Issues" – 5th European Commission Conference on Radioactive Waste Management and Disposal and Decommissioning, 15-18 November 1999, Luxembourg

/4/ Government Response to the House of Lords Select Committee on Science and Technology Report on the Management of Nuclear Waste, Department of the Environment, Transport and the Regions, London, UK, 25 October 1999

/5/ Nirex-97: An Assessment of the Performance of the Post-closure Performance of a Deep Waste Repository at Sellafield, Nirex Science Report S/97/012, December 1997

/6/ Vieno, T., Nordman, H., Safety Assessment of Spent Fuel Disposal in Hästholmen, Kivetty, Olkiluoto and Romuvaara, Report POSIVA 99-07, VTT Energy, March 1999

/7/ Deep Repository for Spent Nuclear Fuel, SR-97 – Post-closure Safety, Main report, TR 99-06, Swedish nuclear Fuel and Waste management Co, Stockholm, 1999

/8/ Plan de Investigacion y Desarollo para la Gestion de Residuos Radiactivos 1999 – 2003, Publicacion Technica 08/99, ENRESA, October 1999

/9/ Boyazis, J.-P., Decamps, F., High-level Waste Management Strategy: A Stepwise approach towards a decision regarding the disposal of high-level waste in Belgium, ONDRAF/NIRAS, Belgium, 1999

/10/ O'Sullivan, P., McKirdy, B., Askarieh, M., Bond, A., Russel, S., Webster, S., Environmental Impact Assessment and Geological Repositories for Radioactive Waste, EURADWASTE'99, 15-18 November 1999, Luxembourg

/11/ Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment (OJ L 175 05.07.85 p.40)

/12/ Council Directive 97/11/EEC of 3 March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment (OJ L 073, 14/03/1997 p.0005-0015)

/13/ Ryhänen, V., The Finnish Final Disposal Programme Approaching Site Selection, Proceeding ENS Topseal'99, Antwerp, Belgium, 10-14 October 1999

/14/ Tamborini, J., Radioactive Waste Management in France – How successive crises helped the process, ANDRA, France, 2000

/15/ Röthemeyer, H., Statement at the panel discussion at EURADWASTE '99, Luxembourg, 15 – 18 November 1999

/16/ Fifth General Radioactive Waste Plan, Miner, Minesterio de Industria y Energia, Madrid, Spain, July 1999

/17/ SKB RD&D-Programme 98, Treatment and Final Disposal of Nuclear Waste, Stockholm, Sweden, September 1998

/18/ Holmes, J., Murray,C., Davies, M., Development of the Institutional Framework for the Deep Repository Programme in the UK, Proceeding ENS Topseal'99, Antwerp, Belgium, 10-14 October 1999

Annex 1

Programmes and plans for management of high level waste and spent fuel in some EU Member States /13 – 18/

Belgium

Belgium is reprocessing its fuel and plans to dispose of the high level and long lived waste in a clay formation. Investigations have since long been concentrated around the Boom clay at the Mol-Dessel site. Here an underground research laboratory, HADES, was built in the early 1980's and continuously being used for scientific and technical studies of disposal. Other sites are also considered. As the allowable thermal load on the clay is low, an interim storage period of at least 50 years is foreseen. The time schedule for a decision on a repository is thus quite extended with the submission of a Preliminary Safety Assessment Report as a first step in 2013.

Since a few years also the disposal of spent fuel is being investigated, as the future reprocessing is subject to discussions.

Finland

Finland plans to dispose of the spent fuel directly encapsulated in a copper canister. The construction of a repository is planned to start in 2010 and operation in 2020. Finland is well advanced in the site selection process. Recently Environmental Impact Assessments have been made for four sites and one site, Olkiluoto has been selected as the preferred site by the agency, Posiva. The process for obtaining a Decision in Principle for this choice by the Council of State is well advanced. During the preparation of the Environmental Impact Assessment Report the public has been extensively consulted. In the work alternative approaches have also been assessed, such as transmutation or postponing the decision.

France

Deep disposal of high level vitrified waste has been the main option in France since many years and reconnaissance activities was performed in the 1980's. After opposition of the public and elected representatives, the Government decreed a moratorium in 1987 and a Parliamentary Commission was set up. In December 1991 the Law concerning research on radioactive waste management was made.

The Law defined a threefold research programme:

- Research for solutions based on separation and transmutation of long lived radioactive elements present in the waste in order to reduce their toxicity;
- Study of the possibilities of reversible or irreversible disposal in deep geological formations, notably through the construction of underground laboratories;
- Study of waste packaging and long term surface storage processes.

At this stage none of those research venues prevails over the two others. In 2006 (after a period of 15 years), Parliament will be empowered to decide whether to build a disposal facility or not, based on a proposal to be made by the Government and a report to be prepared by an independent National Review Board (already in existence).

As concerns the disposal option an important step was made in December 1998 when the Government authorised ANDRA to construct and operate two underground laboratories, situated in clay and granite formations, respectively. The first site is located in a clay formation at Bure in eastern France, while the second laboratory will be excavated in a granitic formation yet to be determined. Construction work is expected to begin in Bure in the second half of 2000.

Germany

Germany is considering to dispose of spent fuel, vitrified high level waste and other heat generating wastes at the same site. It is agreed that geological disposal is the preferred option for managing all kinds of radioactive waste. Until now practically all efforts have been concentrated at the salt dome in Gorleben, where extensive investigations have been made. Two shafts have been sunk to about 840 m depth and connected by an extensive system of exploration galleries. Germany has also performed some generic R&D in crystalline rock in the Swedish and Swiss underground laboratories.

With the change of Government in 1999 discussions have started to revise the waste management plan. To this end a working group has been set up to develop site selection procedures based on scientifically sound criteria. The time needed for this task is estimated to be about 3 years. The procedures and criteria aim at finding the relatively best site in different host rocks in Germany, and the work in Gorleben has been suspended awaiting the outcome of this work. The German Government is aiming at disposing all types of radioactive waste in one geological repository. It should be in operation around 2030.

Spain

The Spanish research has been directed towards direct disposal of encapsulated spent fuel, and a large number of zones, which from a geological point of view might be valid, have been identified. In parallel significant progress has been made in the designs of disposal systems for different geological media.

In July 1999 the Fifth General Radioactive Waste Plan was published. This new Plan changes significantly the approach and time schedule of the spent fuel and high level waste strategy. It states that no decision on the final solution for these wastes will be made until 2010. Until then no further geological studies will be made, but the knowledge and competence on disposal will be kept. In parallel R&D on partitioning and transmutation will be promoted in order to evaluate the feasibility and implications of these new technologies.

Sweden

Sweden plans to dispose of spent fuel directly encapsulated in a copper canister. The work is performed according to a time schedule that will permit an early start of disposal, while allowing ample time for technical development, site investigations and public consultation. In situ research and technological development in the Äspö underground research laboratory has an important role. Direct deep disposal in crystalline rock is the preferred option. The technology of partitioning and transmutation is followed but is not part of the strategy.

At present technical, geological and socio-economic feasibility studies are performed in 6 municipalities. In 2001 it is planned to select at least two sites for site investigations. If found suitable one of this sites will be chosen for detailed site investigations, including a tunnel down to the possible repository area. The process for site selection is step-wise with clear milestones and possibility to retract. As a first step the repository will be built for about 10 % of the spent fuel with the possibility to retrieve it afterwards. The enlargement to a full repository requires a new licensing.

United Kingdom

The spent fuel in the UK is planned to be reprocessed, and the waste to be disposed of in geological formations. Until now the activities have been concentrated on the disposal of the large volumes of long lived low and intermediate level waste as described above. The high level vitrified waste is planned to be stored for at least 50 years. Following the rejection of the Rock Characterisation Facility at Sellafield site a reconsideration of the waste management policy and strategy is taking place.

An important first step has been a House of Lords Select Committee Enquiry, that was reported in March 1999. Some recommendations of the committee were:

- The Government should develop a fully comprehensible policy for the long-term management of all nuclear waste. The policy should be endorsed by Parliament, as well as have public acceptance.
- The consultation should state the problem, the possible solutions and the principal means for implementation of that policy, including, for deep repositories, the site selection process.
- The site selection process should be open and transparent and should involve the public, Parliament and Government.
- The Government should act without delay. The programme for repository development is a long one and cannot be rushed.

The Committee also makes recommendations about the organisation of the work and a step wise decision process with long term possibilities for retrieval.

As a response to the recommendations the Government has announced that a widespread consultation on the best way to manage radioactive waste will start in 2000. The policy must be developed in the most transparent and open-minded way to ensure maximum public acceptance.

Other countries

Also in Italy and the Netherlands the policy is deep disposal in geological formations. As the waste is planned to be stored for 50 – 100 years before disposal very limited resources are dedicated at present to study disposal. The Member States that don’t have a nuclear power programme also have no plans for disposal of long-lived wastes. The small volumes of waste that is generated from other uses are stored for the time being.