

Radioactive Waste Management

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# **A Common Objective, a Variety of Paths**

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on Geological Repositories  
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NUCLEAR ENERGY AGENCY  
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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## FOREWORD

Radioactive waste arises from the operation of nuclear power plants and from the use of radioactive materials in medicine, industry and research. Methods for the safe, interim management and storage of all types of radioactive waste are available and are being implemented in all countries that possess such wastes. In general, disposal is the final aim and wastes are being stored until suitable disposal facilities are available.

Disposal facilities for short-lived, low- and intermediate-level radioactive waste are already operating in many countries. For high-level radioactive waste (which includes spent nuclear fuel if treated as waste), disposal in an engineered repository in a deep, stable, geological formation – geological disposal – is the preferred long-term management option in all countries where a decision on the final end point has been taken.

Geological disposal is widely accepted as a scientifically sound method of ensuring the long-term safety and security of radioactive waste isolation that can be implemented using currently available technology. An international framework has been established to promote and assess the safety and security of radioactive waste management activities, including geological disposal, and is incorporated in international conventions, national laws and regulatory guidance.

In modern societies, however, the implementation of any major new technological project, besides proving its technical merits and safety, must also satisfy societal and political requirements; this has been a particular challenge to geological disposal in many countries. Thus, while the goal of deep geological disposal is widely accepted, the path towards implementation depends on a variety of factors including the national political and legislative framework, economic conditions and the societal or cultural approach to decision making.

There is a practical need to move forward with geological disposal projects in order to deal with the long-term waste liabilities of past and committed nuclear power programmes. Progress towards the implementation of geological disposal has been made in several countries but, in other countries, progress has been slower than expected, or in some cases halted in order to review options or to allow experience to be developed further internationally.

The conference brought together high-level representatives from government, the social sciences, repository implementation organisations, regulatory bodies and international organisations to present information and views from their perspectives as well as to discuss the interfaces of their expertise and implications of their experience. The conference was successful in gaining a shared understanding of the paths leading to geological disposal that are being followed in different countries and, based on this, in assisting national representatives in finding and refining social and political ways forward that are most appropriate to their own particular national conditions.

The conference built upon the success of similar international events held in 1999 in Denver<sup>1</sup> and in 2003 in Stockholm.<sup>2</sup> The sponsors of the conference were the OECD Nuclear Energy Agency (NEA), the International Atomic Energy Agency (IAEA), the European Commission (EC) and the International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM). The conference was organised and hosted in the city of Berne by the Swiss National Co-operative for the Disposal of Radioactive Waste (Nagra).

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1. US Department of Energy (2001), *Proceedings of the Conference on Geologic Repositories: Facing Common Challenges: 31 October-3 November 1999, Denver, Colorado*, USDOE, Washington, D.C.
  2. Nuclear Energy Agency (2005), *Geological Repositories: Political and Technical Progress, Workshop Proceedings, Stockholm, Sweden, 7-10 December 2003*, OECD/NEA, Paris.

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## SUMMARY OF THE CONFERENCE

### **Day 1: Ensuring political and institutional legitimacy**

#### *Opening addresses*

The opening address was given by **Moritz Leuenberger**, Swiss Federal Minister and Head of the Department of the Environment, Transport, Energy and Communications. He drew an analogy between radioactive waste and art or, more specifically, development of geological repositories and development of a gallery such as the Zentrum Paul Klee where the conference was being held. They each represent a legacy or heritage that society seeks to preserve or protect over long times. Everyone has an interest and wants their say on such long-term social assets and projects. Progress is only possible in conditions of open dialogue involving all parties irrespective of standpoint or views. It has to be acknowledged that we cannot foresee the future, but we can imagine and consider possibilities. Having considered the problem, commitment is needed at all levels to finding acceptable solutions and taking collective responsibility for pre-existing decisions (producing the waste in the first place) and for decisions that still have to be made. Time is needed, not only from a technical point of view, but importantly to develop the necessary social understanding and acceptance – “you cannot make the grass grow faster by pulling it!” Switzerland is now at the beginning of the process of implementing the repositories it needs; the rules and guidelines for the siting process have been set out and it can now move forward with the involvement of all interested and affected parties, knowing what the objectives and conditions are for the process.

An address on behalf of the conference sponsors was given by **Luis Echávarri**, Director-General of the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD). L. Echávarri referred to the “triple curse” of radioactive waste: waste is something we are taught to reject, radioactivity is both mysterious and dangerous and it is associated with nuclear energy production. Dealing with these negative feelings goes beyond the competence of the technical specialists and the past emphasis on technical issues may even have hampered the development of social understanding and acceptance. Moving forward requires trust in the technical specialists, but also environmental, educational and energy policies that allow the technical specialists to play their roles alongside other actors within a transparent decision-making process. At one time, disposal was viewed as a relatively short-term activity along a path to be defined at the outset. Now, the implementation of a disposal project is viewed as an incremental process, in which future generations will also be involved in making decisions. Such a project requires the long-term commitment of society and its political leaders based on environmental and energy policies that fully incorporate principles of long-term safety and sustainable development. Hence the value of a forum such as this conference where, through the exchange of information with other colleagues faced with similar tasks worldwide, decision makers and opinion leaders can become better informed of progress, current debates and plans.

#### *Keynote addresses on strategic and policy developments*

At the highest level, senior national representatives and leaders of international organisations must set the strategic goals and the framework to allow important national projects, such as the development of a nuclear waste repository, to proceed. In order to achieve practical implementation, this framework must provide processes for reaching technically sound and safe solutions that are also acceptable from social and political perspectives.



Session 1 consisted of keynote addresses by political representatives from France, the USA, Japan and Germany, by senior representatives of international organisations – the OECD/NEA, IAEA and EC – and by the chairman of the Swedish National Council for Nuclear Waste. The addresses covered views on the role of government and international organisations and practical experience in different countries with the implementation process from political, legislative and public perspectives. Some key points that were made are as follows.

Radioactive waste is the inevitable consequence of nuclear energy programmes and, independent of the future of nuclear energy and of the fuel cycle chosen, high-level waste (including spent nuclear fuel) has already been produced and requires safe and secure management. **Greg Schulte**, U.S. Ambassador and Permanent Representative to International Organisations in Vienna, remarked that new nuclear energy construction is needed to meet future energy needs, while also limiting carbon dioxide emissions. **Tomihiko Taniguchi**, Deputy Director-General, Nuclear Safety and Security, International Atomic Energy Agency (IAEA), noted that the failure to resolve the high-level waste disposal issue had left a legacy of doubt on the part of the public and politicians regarding the overall safety of the nuclear cycle. **Georg Arens** of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany) stated that, in his country, the future role of nuclear energy in electricity production significantly influences the debate on radioactive waste disposal.

Geological disposal is an essential element of the management strategy for high-level radioactive waste. **Claude Birraux**, Member of the French National Assembly, First Deputy-Chairman of the Parliamentary Office for Scientific and Technological Assessment (France), **Kenji Ogiwara**, Vice-Minister, Ministry of Economy, Trade and Industry (Japan), and **Zoran Stančić**, Deputy Director-General for Research (EC), noted the importance of research in both national and international programmes. This may eventually lead to alternative or improved solutions, but no speaker challenged the claim that, for the waste from existing programmes, geological disposal offers the required long-term safety and is technically feasible now. In this light, “wait and see” is not considered an acceptable approach and is not sustainable. L. Echávarri noted that such an approach is unethical and potentially unsafe. G. Schulte noted that the sooner one country dispels the myth of “no solution” by siting, licensing and operating a high-level waste repository, the easier it will be for others to follow.

All countries that produce high-level radioactive waste have a duty to ensure its safe and secure long-term management, which is also the responsibility of national governments. K. Ogiwara described how the Japanese government has set the legal framework for implementation of the final disposal project, envisioning a volunteer process in which full regard will be paid to the wishes of municipalities and prefectures (regions), although it is considered that further publicity and encouragement is now needed to promote the project. C. Birraux described how the French Parliament has taken, and continues to take, direct responsibility for the process leading towards final management solutions through national legislation with defined objectives and decision points; he also noted that solutions need to be implemented within each country, which is a view accepted by most countries and fixed in law in several cases. T. Taniguchi, however, noted the possibility of shared nuclear cycle facilities, including repositories, which would have cost advantages for countries with small nuclear programmes. G. Arens pointed out that repository safety begins with a transparent site selection process, on which the German government’s efforts are currently focused.

Both L. Echávarri and T. Taniguchi emphasised the strong common international safety framework that is in place through the Joint Convention<sup>1</sup> and IAEA Safety Standards, and the importance of information exchange and discussion that takes place under the terms of the Joint Convention, the CPPNM<sup>2</sup> and within the fora offered by international organisations.

### ***Panel discussion on strategic and policy experience***

The panel session featured political representatives from Germany, Switzerland, Belgium and France, each with experience related to the development of radioactive waste disposal policy or projects in their own countries, regions or municipalities, plus a senior representative of the EC. The session was chaired by **Elizabeth Dowdeswell**, Special Advisor to the Board, Nuclear Waste Management Organisation (NWMO), who led the public engagement process on nuclear waste management approaches in Canada.

E. Dowdeswell identified three trends or issues that appear to be common to the debate on nuclear waste disposal across countries: the linking (or not) of the need for waste management solutions to future energy policy; the increasing trend of engaging citizens in complex policy decisions, which is a new factor for nuclear energy; and the need to reconcile the long time needed for development of nuclear waste management solutions with the relatively short timescale of political mandates. She then invited the panellists to describe how the debate on such issues had unfolded within their respective jurisdictions.

**Volker Giraud**, Head of the Section “Disposal and Decommissioning”, Ministry of the Environment of Baden-Württemberg (Germany), observed that, following a twenty-year long licensing phase and the exhaustion of all legal options, work has now started on converting the Konrad mine for the disposal of low-level and intermediate-level radioactive waste, commencing waste emplacement in 2013. In the case of high-level waste, however, despite more than 30 years of work it has not been possible to find a final repository site that is acceptable to all those involved. At present, the process is halted for political reasons – the German states have confirmed through resolution of the Federal Council that the Gorleben salt dome is a suitable final repository location, but the Federal Environment Ministry believes that a new search should be initiated for a final repository location. He also noted the issue of development of a repository close to national borders, which could be the case for a Swiss repository close to the German border; communication is needed between neighbours since the neighbouring country is also a stakeholder.

**Ute Blohm-Hieber**, Head of the Unit for Nuclear Energy, Waste Management and Transport, Directorate-General for Energy and Transport (EC), addressed four questions related to geological disposal: What has been done so far? What has been achieved? How is it communicated? What are the consequences? There have been extensive research and development and some pilot demonstration experiments. This has led to consensus on the suitability of the concept and that technical aspects are mainly solved. This, however, does not seem to have been well communicated to the public, which has consequences for the public view of both geological disposal projects and attitudes towards new nuclear electricity production. This is illustrated by the results of the Eurobarometer surveys. U. Blohm-Hieber concluded that, while acknowledging that some technical and scientific issues remain open, technical experts must make clearer positive statements on the safety, feasibility and wealth of technical experience related to geological disposal.

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- 1 International Atomic Energy Agency (1997), *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, INFCIRC/546, IAEA, Vienna.
  - 2 International Atomic Energy Agency (1980), *Convention on the Physical Protection of Nuclear Material (CPPNM)*, INFCIRC/274 Rev. 1, IAEA, Vienna.

**Hannes Germann**, Member of the Council of States (Switzerland), gave an overview of the Swiss situation and programme. The system of direct democracy in Switzerland, with national and cantonal referenda, means that the public are experienced in assessing and making decisions on controversial and difficult issues, and that technical issues have to be communicated to the public. An energy shortfall is forecast in Switzerland that will leave the country to some extent dependent on imported electric power. Partly in this light, two referenda against nuclear power generation and further build were both defeated. In the case of the proposed repository for low- and intermediate-level waste at Wellenberg, although the local community was in favour of development, the project was rejected by cantonal referendum. The responsible federal ministry has now set out a staged process for siting geological repositories in Switzerland (the so-called “sectoral plan”), which assigns highest priority to safety and suitable geological locations, but also takes account of the local environmental and infrastructure implications and related concerns of the potential host cantons and municipalities, as well as neighbouring regions.

**Kris Van Dijck**, Member of the Flemish Parliament and Mayor of Dessel (Belgium), outlined the process and experience with the local partnership arrangement between the municipality of Dessel and the Belgian waste management agency (ONDRAF/NIRAS) in bringing forward the project for near-surface disposal of short-lived radioactive waste. This process, which was undertaken in line with decisions of the federal government and developed by ONDRAF/NIRAS in collaboration with interested communities, has been a very positive experience. The process has been carried out with full local participation (partly in view of existing local experience in nuclear matters around the Mol-Dessel nuclear site) and with technical guidance and information from ONDRAF/NIRAS. He concluded that, when members of the public have sufficient opportunity to obtain information and can judge that there is technical honesty regarding the problems and possible solutions, then they are willing to engage and are fully capable of contributing positively to a project.

**Cyrille Vincent**, Directorate-General for Energy and Raw Materials at the Ministry for Ecology, Sustainable Development and Spatial Planning (France), pointed out that a common basis is needed in all national policies – they must be transparent, incorporate sound economic decisions and assumptions, have a sound scientific and technical basis and be sustainable, particularly with regard to long-term financing. He outlined two examples of French national policies in these terms. With regard to the long-term management of radioactive waste, policy was initially defined by the law of 1991 and now by the law of 2006. Future generations must be protected from the wastes that are produced and the cost of providing protection must be contained within the costs of the activity that creates the waste, i.e. electrical power generation. The law ensures that sufficient funds are set aside and puts the government in control over major decisions to be taken in developing waste management solutions. The nuclear power companies report to the government and the process is overseen by regulatory authorities from both technical and financial perspectives.

Questions from the floor were taken and discussed by the panel. The points raised and discussed were as follows.

Since the US National Academy first recommended geological disposal, there has been a history of 50 years of research and development related to this option. There is also sufficiently extensive experience to allow it to be said that the full set of tools is available for developing, assessing and licensing a geological repository. The view was expressed that a key reason why no repository for high-level waste exists is that the volumes of waste are small and can be stored safely and economically. The power utilities are content with this position and progress will only occur when political pressure is applied to develop a repository.

It was observed that the link between geological disposal and new nuclear energy construction makes the question much more complex. The panel were asked their views on retrievability. The panel considered retrievability to be important because developments are possible; retrievability is a legal requirement in some countries.

It was noted, for example from the Belgian experience, that it may be easier to gain acceptance for siting in communities that already host nuclear facilities. However, the question is how to find a balance between a location with some local support that is “good enough” and potentially “better” sites elsewhere. This was not directly answered, but could depend on national policy or approach, for example as set out in the Swiss guidance on siting.

There is a range of possibilities for international cooperation, from sharing knowledge and experimental facilities – which has been very successful – to sharing waste management facilities, which, in the future, might include sharing a geological repository. The EC would, in principle, be supportive of a shared repository, but a host country is needed. On the other hand, most countries will have to find their own solutions to their waste management problems, which may also be prescribed by law.

The view was expressed that two ways to damage progress towards geological repositories were to try to find a best site and to talk about regional repositories, which would be counter to national approaches. A third would be to make a link to new nuclear power; this would be detrimental to the progress of geological disposal and it is essential to decouple the issues. The opposite view was also expressed: a positive move towards nuclear power could be beneficial and ease the way to development of geological repositories.

In summing up the session, E. Dowdeswell considered that there were five key messages to be derived from the discussion. There have been some successes, but also setbacks in some countries. Communication is very important – this should be positive about the technical merits, must include all parties irrespective of views and include neighbouring countries. Different modes of decision making can be observed in different countries – referenda, facilitated national debate and local partnership approaches. While technical arguments were once dominant in proposing geological disposal, the question of implementation is now being approached from the viewpoints of sustainable development, financial considerations and social acceptability. Whatever the national process, there is an absolute need for those leading the process to demonstrate integrity.

### ***Closing remarks of day 1***

**Walter Steinmann**, Director of the Swiss Federal Office of Energy, made closing remarks on the first day as follows.

Independent of the future of nuclear energy and of the fuel cycle chosen, high-level waste and spent fuel has been produced and requires safe and secure management. Geological disposal is an essential element of radioactive waste management. To wait and see is not an acceptable approach; it is neither ethical nor sustainable.

Nuclear waste management is a controversial issue and its associations (waste, radioactivity, nuclear power) create fear. Acceptance of disposal projects is intrinsically difficult to achieve, but public acceptance is recognised as being essential for the implementation of geological repositories (as for other large-scale projects). There is a need to involve society in the decision-making process. Many countries have a legal obligation to manage their own waste only and within their own territory

We need clear political leadership, knowledge and responsible stakeholders (government, cantons/states, communities, implementer, regulator, etc.). We need a waste management strategy and a stepwise decision-making process that ensures the involvement of society. Finally, we need a legal framework that allows implementation of both the strategy and the decision-making process.

We have to accept that implementation of geological disposal will need time – pulling the grass will not make it grow faster. Finally, sound science and high quality technology are essential to ensure safety and security and are a prerequisite for successful implementation.

## **Day 2: Ensuring protection, creating trust and bringing national projects forward**

Implementing disposal of high-level radioactive waste in a geological repository within the political and legal framework discussed on Day 1 is a challenging prospect.

To implement repositories economically, and with due regard to social factors, the processes for decision making and the technical and social requirements to be met at each step of implementation need to be fairly established and well understood. To achieve this, multiple actors – industry, regulators and political as well as institutional representatives – will need to communicate effectively with each other and with the public. Having established the process and requirements, they will have to work together to carry projects through. Discussion of the approach is necessary, but cannot be open-ended or indefinite.

The following sessions explored the processes for decision making and implementation of geological repositories from the perspectives of societal involvement, practical implementation and regulatory supervision.

### ***Societal aspects***

Controversial scientific developments and major technical projects are valid subjects for public debate and decisions on whether and how to implement such developments or projects must take account of societal concerns and opinions. To achieve an informed public debate, it is necessary to provide information on the issues at hand, on realistic alternatives and their impacts. The siting of a geological repository in particular poses social and ethical questions – should a region hosting nuclear facilities also be expected to host final disposal facilities? Should siting be based on a volunteer process? To what extent are compensatory, economic, amenity or financial benefits legitimate? For a geological repository, the debate becomes most critical when it is focused within the community, municipality or region that may host the repository.

Claude Birraux, Member of Parliament, First Vice-Chairman of the Parliamentary Office for Scientific and Technological Assessment (France), introduced the session, which included a presentation of the framework for ethical and societal issues and examples of experience from Canada, Switzerland and Sweden. He outlined principles for good governance – a clear definition of the framework at the national level, safety as a prerequisite, understandable information and communication, local participation and local and regional benefits. He also drew attention to ten “tips for action” given in the OECD Handbook *Citizens as Partners*.<sup>3</sup> These are: 1. Take it seriously, 2. Start from a citizens’ perspective, 3. Deliver what you promise, 4. Watch timing, 5. Be creative, 6. Balance different interests, 7. Be prepared for criticism, 8. Involve your staff, 9. Develop a coherent policy, 10. Act now.

**Carl-Reinhold Bråkenhielm**, Swedish National Council for Nuclear Waste (KASAM), gave a presentation on the ethical ideas and choices stemming from the concept of sustainability, based on the

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3. Nuclear Energy Agency (2001), *Citizens as Partners, OECD Handbook on Information, Consultation and Public Participation in Policy-Making*, OECD, Paris.

work of ethicists and moral philosophers. He distinguished between “weak sustainability”, which can be achieved by considering the value or cost of economic assets and liabilities that are passed on to the next generations, and “strong sustainability”, which asserts that natural capital cannot be reduced to monetary capital and that restraints are needed to protect ecological and environmental systems. Implementing strong sustainability, although it may be morally preferable, raises problems of ignorance, distance and extent – we do not know what future generations will want and need (ignorance); is it meaningful to speak of a moral responsibility to remote generations? (distance); how extensive are our obligations to future generations? (extent). He introduced a scale of diminishing responsibility based on alternate principles of justice that could be appropriate for considering our moral obligation over different future timescales – over very long times, to avoid harming future generations (minimal justice); over intermediate times, to satisfy future generations’ basic needs (medium justice); over shorter times, to contribute to future generations’ effort to achieve a quality of life at least equal to ours (maximal justice). Finally, he noted the idea of the rolling present. In this, the ethical imperatives could be to preserve the gains that our culture and civilisation have made for posterity, to keep our institutions and those institutions that maintain justice intact and to pass on to future generations a greater capital in the form of more knowledge and better developed technology than we ourselves received from previous generations.

**Kathryn Shaver**, Nuclear Waste Management Organisation (Canada), described how the NWMO sought to develop a recommended management approach collaboratively with Canadians. This was achieved through a process of engagement with citizens and specialists using a wide variety of communication and dialogue tools. From this dialogue, common ground emerged concerning values, ethical principles and objectives that are key to choosing a management approach, the desire to consider a new approach, building on the strengths of other options and principles and expectations for implementation. Societal requirements for implementation were presented, including factors related to timing, future choices, adaptive technology, safety as a priority siting to meet social and ethical requirements, aboriginal rights, information and communication and preparing future generations for their responsibility. The “Adaptive Phased Management” approach that has been selected is designed to satisfy these requirements. The NWMO faces a continuing challenge and is committed to embracing adaptability guided by ongoing dialogue and new learning, providing an inclusive, collaborative decision-making process and being an open, transparent and accountable learning organisation.

**Michael Aebersold**, Swiss Federal Office of Energy, described the radioactive waste management policy and plans in Switzerland and, in particular, the new federal ministry sectoral plan for deep geological repository development. The plan defines a three-stage selection process based on geological suitability, regional and local implications and technical choices between sites. The underlying goals of the approach are consideration of all interests and concerns by involving the public, transparent handling of conflicts, fulfilment of expectations and creation of win-win situations. The procedure is designed to ensure fairness and transparency, joint definition of the rules, a step-by-step approach and open information. The plan defines broad consultation and foresees the early and continued involvement of society at all levels (regional, affected parties and interest groups, individuals). This participatory approach does not ensure the success of a project, but should promote its acceptance.

**Jacob Spangenberg**, Mayor of Östhammar, and **Kaj Nilsson**, Project Manager LKO – Competence building on nuclear waste issues in Oskarshamn municipality (Sweden), jointly presented the experience from the viewpoints of their respective municipalities. These municipalities, which already host nuclear power facilities, have both agreed to take part in pre-feasibility studies followed by site investigation and feasibility studies related to siting of the Swedish final repository for spent nuclear fuel. The working structures and methods by which the municipalities engage in the process were described. J. Spangenberg noted the key principles of their engagement: local politicians will make final decisions, municipal residents need to have confidence in the overall process and

neighbouring municipalities and local NGOs must be allowed to participate. K. Nilsson noted that the process is as important as the content – it is necessary to define the actors and their roles, define participation (how and when) and realise the importance of the regulator. A local veto empowers the public and the local decision makers. He reported that local opinion polls showed that the balance of views in Oskarshamn had consistently moved in favour of the project over the period of engagement.

### ***Implementation aspects***

The nuclear industry is responsible for ensuring the safe management of the radioactive waste it produces within international safety guidelines and within the policy and regulatory framework developed by national governments. This includes the development, operation and closure of radioactive waste facilities and provision of the necessary finances. Repository developers in many countries have substantial experience in technical areas of implementation, assessment and presentation to regulators. Experience of developing and managing societal input to repository decision making is more limited. This remains an area in which repository developers are open to learn and anticipate that the development of the necessary dialogue, taking account of specific national and local characteristics, will be an ongoing challenge.

Luis Echávarri (OECD/NEA) introduced the session, noting that each of the four speakers represented a different stage in the repository development process, a different geology, a different canister design, different logistical undertakings and a different regulatory and societal context. The session was organised as a panel discussion, with short presentations from each speaker followed by discussion with the audience.

**Kenneth E. Nash**, International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM) and Nuclear Waste Management Organisation (NWMO, Canada), briefly mentioned EDRAM<sup>4</sup> and its objectives and then went on to describe the history of the Canadian nuclear fuel waste management programme. Key lessons learned have been that it can take a long time to recover from failure in siting, that the pace of implementation must be consistent with societal pace (and societal expectations can change) and that relationship building as well as collaborative planning are needed. He identified special factors surrounding the siting of a nuclear fuel waste repository in Canada – the distinct cultural and legal status of the aboriginal people, geographical size, the extent of relationship building prior to siting, the influence of new build nuclear proposals and possible entry of Canada into GNEP.<sup>5</sup> He also mentioned the positive progress with respect to the geological repository for low- and intermediate-level radioactive waste in the municipality of Kincardine.

**Marie-Claude Dupuis**, National Radioactive Waste Management Agency (ANDRA), outlined the implementation process for geological disposal in France. Progress along the lines mandated by the law of 1991 (investigation of alternative solutions, operation of a URL, demonstration of the feasibility of a safe repository in a clay formation allowing for reversibility (Dossier 2005), organisation of support to local development, etc.) enabled formulation of the new policy set out in the law of 2006. Under this law, solutions formerly seen as alternatives are considered as complementary. ANDRA is responsible for waste storage and disposal, while ANDRA and the CEA will work together on the disposal of waste from future nuclear cycles. This is included in a National Radioactive Material and Waste Management Plan in which all types of radioactive waste are considered within a consistent framework. A stepped-up timetable towards a geological repository has been established, leading to site selection, review by the authorities and a new law defining specific conditions for development of the repository (with provisions on retrievability) by 2015.

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4. EDRAM is an association of CEOs and chairmen of implementers.
  5. The US Department of Energy's Global Nuclear Energy Partnership.

**Claes Thegerström**, Swedish Nuclear Fuel and Waste Management Company (SKB), outlined the implementation of the Swedish concept for deep geological disposal. The method (KBS-3) proposed in the 1970s has been progressively developed over more than 30 years through extensive R&D and assessments. The Government gave the go-ahead for site investigations in the municipalities of Oskarshamn and Östhammar in 2001-2002 and deep drilling has just been concluded. Site selection will be based primarily on safety criteria. Given comparable safety conditions, other criteria, such as environmental impact, will be used. The licence application for the final repository will be filed within a few years. Provided this satisfies the scrutiny of the regulatory authorities and reviewing bodies, a licence will be issued so that construction could start around 2012 and the first canister could be emplaced in 2020. The Swedish programme has evolved over the past 30 years with consensus between the nuclear power utilities and political interests. C. Thegerström identified three important principles behind this process: a regulated stepwise implementation process, clear division of roles<sup>6</sup> and organised local consultation. In particular, the long period of dialogue with the local residents has generally led to increased trust in the implementer.

**Edward F. Sproat**, Office of Civilian Radioactive Waste Management (OCRWM, USA), gave an overview of U.S. nuclear waste policy and its passage towards the development of a geological repository for spent nuclear fuel and high-level waste at Yucca Mountain. The process can be traced back to the 1957 report of the US National Academy of Sciences that recommended geological disposal. Central is the Nuclear Waste Policy Act (NWPA) of 1983 that made the DOE responsible for the disposal of spent fuel and high-level waste, set up the site investigation programme and established the Nuclear Waste Fund. The 1987 NWPA Amendments Act mandated one site (Yucca Mountain) for characterisation, which was designated as the site for the repository in 2002. Licensing is a two-step process – construction authorisation followed by a licence to receive and possess the waste. Closure of the repository must be preceded by a period when retrievability is possible. The NWPA encourages and funds participation by affected units of governments and tribes. The best achievable schedule<sup>7</sup> for Yucca Mountain envisages that the DOE will submit the licence application to the Nuclear Regulatory Commission (NRC) in June 2008 [*the application was actually submitted on 3<sup>rd</sup> June 2008*]. The NRC could then authorise repository construction in 2011, followed by construction for initial operations in 2016 and initial receipt of waste in 2017. Answering a question from the floor, E. Sproat stated that the law should soon be modified to allow an extension of the Yucca Mountain repository beyond the current limit of 70 000 metric tonnes. Alternatively, the DOE will propose to set up a second repository.

In the course of the discussion following the presentations, the speakers stressed that a high-level waste repository would be needed regardless of the evolution of the back-end of the fuel cycle (e.g. Generation IV reactors or re-introduction of reprocessing). L. Echávarri stressed that all projects presented had good chances of success and reminded the audience of the Finnish repository currently in the initial phase of construction.

### ***Regulatory aspects***

**Ulrich Schmocker**, Swiss Federal Nuclear Safety Inspectorate (HSK, Switzerland), introduced this session. The role of the regulators is to establish the regulatory requirements for hazardous processes and facilities in order to protect workers, members of the public and the environment. Regulatory bodies set the requirements for licensing and the procedures for meeting these requirements. They will also specify conditions for the development, operation and closure of facilities and carry out the necessary reviews,

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6. The producers are legally responsible for the waste; SKB acts on their behalf to manage the waste and find a method and site for final disposal. The regulators review SKB's programme and ensure that it meets the requirements on safety and radiation protection.
  7. This schedule depends on timely issue of all necessary authorisations and permits, the absence of litigation-related delays and enactment of legislation proposed by the government.



inspection or monitoring to ensure that the conditions are met. To fulfil their role, regulatory bodies must be independent of political and industry pressures, trustworthy and seen to be acting in the interests of society. Importantly, they must engage in dialogue with the developer or operator and all interested parties to ensure that, while providing sufficient protection and control of potentially dangerous activities, the regulatory requirements are also practicable and appropriate to the facility and hazards.

While all countries base their regulation of geological disposal on a common international framework, the details of its enactment may differ, e.g. due to different legal frameworks and distribution of regulatory responsibilities, differences in geological disposal concepts and historical differences. Discussions within international fora such as the IAEA Waste Safety Standards Committee and the OECD/NEA RWMC Regulators' Forum have enabled regulators to understand these differences and to confirm that, while differences in application exist, common principles of protection and bases for their application are maintained.

**Dale Klein**, Nuclear Regulatory Commission (United States), presented the role of the US NRC. While the US Environmental Protection Agency (EPA) has the legal responsibility for developing environmental and dose-based standards for the Yucca Mountain repository, the NRC will serve as an independent regulator to ensure that any repository adequately protects health and the environment. Independence does not mean working in isolation; the NRC communicates actively with the DOE, industry, the public and other stakeholders, including state, county and local governments and affected Native American tribes. D. Klein observed that promising efforts are underway in the Multinational Design Evaluation Program (MDEP) to share knowledge and experience on power plant design and to promote global convergence in associated codes, standards and regulations. He considered that this model might also be appropriate with respect to geological disposal facilities.

**Jukka Laaksonen**, Radiation and Nuclear Safety Authority (STUK, Finland), outlined the legal and regulatory situation and process leading to the development of the repository for spent nuclear fuel in Finland. The 1994 amendment of the Nuclear Energy Act requires permanent disposal in Finland, with no export or import of spent fuel allowed. The principles behind the Finnish solution are not to leave nuclear waste as a burden to future generations, to take care of nuclear waste using today's proven technology and to manage waste without the need for foreign support. STUK duties include preparation of nuclear safety regulations, safety evaluation (necessary for licensing), inspections to verify facility safety and compliance with licence conditions and inspections on nuclear waste management and material safeguards. Current underground investigations at Olkiluoto are expected to lead to the proponent's application for construction by 2012 and, subject to a STUK review and a government decision, application for an operating licence around 2020. J. Laaksonen identified the elements contributing to the success of the Finnish programme as being a well defined regulatory framework, clear responsibilities and political commitment; quality and transparency of the scientific and technological programme; a stepwise, open and defensible siting process; local and national trust and local socio-economic benefits.

**József Rónaky**, Hungarian Atomic Energy Authority (HAEA), outlined regulatory and policy aspects of radioactive waste management in his country. He described how an attempt to license a site for near-surface disposal of L/ILW at Ófalu during the 1980s failed due to the public opposition. A new law of 1996 on atomic energy defined principles and clear responsibilities for radioactive waste management in Hungary, including the establishment of a Central Nuclear Financial Fund (CNFF). A site selection process led to the identification of the Bábaapáti site for a deep repository, with both the process and the selection being reviewed and endorsed by an IAEA expert mission. J. Rónaky identified key elements of the success of the current process as being the new legal framework, clear assignment of responsibilities (between government, regulators and operator), transparency of the licensing procedures, involvement of the public and financial support of the local municipalities. The most important change was acknowledgment of the national importance of radioactive waste management.

**André-Claude Lacoste**, Nuclear Safety Authority (ASN, France), outlined recent international progress on harmonising the safety requirements for a geological repository. The IAEA Safety Standards are essential for the harmonisation of safety requirements worldwide. Two important recent documents are the new Safety Fundamentals (SF-1)<sup>8</sup> and the Safety Requirements for geological disposal (WS-R-4).<sup>9</sup> The Western European Nuclear Regulator's Association (WENRA) is developing two reports on radioactive waste and spent fuel storage and on decommissioning of nuclear installations. Updated safety reference levels were published in 2007 as working documents. The European Pilot Study was initiated by the French and Belgian safety authorities, now also joined by regulators and technical support organisations from Finland, Germany, Spain, Sweden, Switzerland and the United Kingdom, plus representatives of the IAEA and the EC. The aim is to share regulator experience and opinions on the expectations for different elements of a safety case for geological disposal. The group has produced a report on the regulatory review of a safety case for geological disposal and a report on methodologies for treating the uncertainty in the long-term safety case. The study concluded that regulatory frameworks differ between countries, but that regulatory practice differs much less. A.-C. Lacoste considers that the harmonisation of safety reference levels is desirable and will be reached for some issues related to radioactive waste under WENRA. A first step towards harmonisation of safety requirements for geological disposal is occurring in the European Pilot Study.

### ***The Way forward – Panel discussion***

The final session was a panel discussion among senior representatives from parliament, a waste producer, waste management organisations, a regulatory body and a national oversight body.

The chairman, **Hans Forsström**, International Atomic Energy Agency (IAEA), introduced the session by observing that, in the past two days, information had been provided from different perspectives on where we are with respect to geological disposal and how we got there. The aim of this session was to look forward and to answer the question – how can the political, societal, regulatory and implementation aspects be reconciled to achieve a successful result? He facilitated the discussion by inviting short presentations from each of the panellists and posing key questions. The session began by discussing political and societal aspects and then implementer and regulator aspects.

### ***Political and social aspects***

**Kathy Riklin** is a member of the Swiss Federal Parliament and is also chair *2006-2007* of the Parliamentary Commission for Science, Education and Culture. She noted the importance of exchanging knowledge and networking as illustrated in this conference. In Switzerland, the timetable for implementing a geological repository envisages operation not before 2038 or 2045, despite Nagra having started its work on radioactive waste disposal more than 30 years ago. Time is needed, both in parliament and in wider society, to develop the understanding and the required consensus. A solution is needed irrespective of decisions on future use of nuclear power. The solution of geological disposal is considered feasible today, but retrievability is an important element that leaves alternatives open to future generations. A factor in developing understanding and consensus could be improved scientific education.

Carl-Reinhold Bråkenhielm of the Swedish National Council for Nuclear Waste (KASAM) also noted the value of such a conference in terms of what the participants can take back to their national

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8. International Atomic Energy Agency (2006), *Fundamental Safety Principles*, Safety Fundamentals No. SF-1. IAEA, Vienna.
  9. International Atomic Energy Agency and Nuclear Energy Agency (2006), *Geological Disposal of Radioactive Waste. Safety Requirements*. IAEA Safety Standards Series WS-R-4. IAEA, Vienna.

situations. He raised the issue of public dialogue – it is very important but not easy, and can be a double-edged sword. He illustrated this by a very recent case of a newspaper article in Sweden that cast doubt on the corrosion resistance of copper (key to safety in the Swedish concept), based on views from a research institute. SKB and the regulators responded immediately, stating that the issues raised were well known and had been thoroughly researched and assessed as not being detrimental to safety. He noted that today science speaks to the public, but the public also speaks back. Scientists, regulators, etc. need to consider the nature of society and how it interprets scientific results.

H. Forsström focused on this point – we need to be open and to say things are in good shape, but the media will draw attention to “bad news”. How do we adapt ourselves to this situation?

**Bruce McKirdy** of the Nuclear Decommissioning Authority (NDA, United Kingdom) summarised the status of the government’s “Managing Radioactive Waste Safely” programme. Following broad consultation, the CoRWM committee recommended geological disposal as the appropriate method for long-term management. The government has accepted this and the focus of the programme is now on the approach to political and social implementation. A siting process based on principles of volunteering and partnership has been developed, particularly with the assistance of the Forum of Local Authorities (FLA). Their main concerns included the right to withdraw and the negotiation of benefits. He noted that, while the discussion was centred on the general (*i.e.* not localised) process, there was little media interest.

**Hans Issler** of the Swiss National Cooperative for the Disposal of Radioactive Waste (Nagra) said that, in Switzerland, public involvement is very important and has been included in defining the rules of the siting process. He also noted that public concern only becomes acute when the development occurs “in their own backyard”. He considered that the regulators have a very important role as independent experts supporting the public. Both implementer and regulator must develop the confidence and trust of the public and must also involve the public.

**Manfred Thumann** is vice-president of Axpo Holding AG, Switzerland, which owns and operates nuclear power plants. He noted that the media need news and that bad news is more interesting. The response should not just be to kill the sensation in bad news, but to recognise a positive opportunity. The public may not be able to follow the details of a scientific question, but they should see that we are 100% serious about following up each and every issue. Hence, the response is either yes we know about this and have resolved the issue in this way, or we do not know but will follow it up immediately and let you know. It is important to be seen even if it is sometimes negative.

H. Forsström asked at what level public involvement would be needed or most important.

**Jean-Paul Minon** of the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS) replied that this depends on the decision. National public involvement is needed for the fundamental policy and concept decisions and local public input is requested with respect to siting and local developments. This approach was being followed in Belgium, with decisions first at the national level with all options on the table and then implementation at the local level following a fair process. He observed that the media are neither good nor bad but are simply professionals with a job to do – to put news (and information) at the disposal of the public. Dealing with the media is also a professional skill that needs to be learned through appropriate training.

**Jukka Laaksonen** of STUK, the Finnish regulator, noted that it is not good to respond aggressively, but rather it is better to “train” journalists in advance. STUK has held courses for journalists to inform them of the issues involved and has gained a position as a trusted source, so that in the event of a story, these journalists ask for STUK’s view. With regard to the general situation in

Finland, J. Laaksonen affirmed Finnish policy principles and views – we have no right to leave nuclear waste as a problem to future generations, wait and see is not acceptable – a solution must be implemented if nuclear power generation is to continue – and finding a solution within national borders is possible for all countries irrespective of geology. Policy makers, implementers and regulators must define the path and move forward with existing technical methods and resources. The drivers are changing – sustainable development, clean energy requirements, increased safety and economy – but the general principles and therefore the need to move forward still remain.

H. Forsström noted that this was a politically sensitive point. Do we agree on the link between future nuclear power and implementation of waste management solutions? Is a new nuclear power plant possible without a waste management solution?

M. Thumann observed that it does not matter what we think. Opinion polls clearly show that the public considers nuclear power and waste management as being connected. The public wants to see a solution for nuclear waste disposal and this is needed before committing to the next generation of nuclear plants. The public may need to see practical demonstrations as well as technical reports.

K. Riklin noted that national votes in Switzerland have been against phasing-out of nuclear power generation, but the green parties are against geological repositories, knowing that the lack of solutions for waste disposal could also freeze new nuclear development.

B. McKirdy noted that, in the United Kingdom, there are two separate consultations – one on nuclear power (recently completed) and one on managing radioactive waste. The government is of the view that, since CoRWM has recommended a solution for nuclear waste that they judge to be feasible, there *is* a solution – it is only the path for implementation that is still in question. This view on waste solutions is carried to the deliberations on nuclear power. Issues of security of supply and the need for clean energy have led the government to adopt a positive attitude to new nuclear build; this is a clear shift from a decade ago.

C.-R. Bråkenhielm favoured separation of the issues, at least at the political level. We, including the opponents, have a common objective to dispose safely of existing and committed waste. The opponents may engage in the discussion on nuclear waste if the separation can be made. J.-P. Minon agreed with this, but would turn the point around – it is irresponsible to block radioactive waste disposal on account of a lack of agreement on future energy policy.

H. Forsström asked who should separate the issues. C.-R. Bråkenhielm considered that only the politicians could do this. H. Forsström invited questions and comments from the audience.

On the issue of “to communicate or not”, it was observed that you may avoid criticism by saying nothing, but if you say nothing then someone else will say something.

On separation of new nuclear build and waste disposal, it was pointed out that you cannot separate the issues unless the opponents do. The question of new nuclear build could, however, be more urgent and important than that on nuclear waste. This was acknowledged, but we could still question the link and argue to separate the issues in order to make progress – perhaps engaging the opponents in a new dynamic. It was observed that nuclear waste was a subset of the issues surrounding new nuclear build and we must therefore handle the waste issue first.

#### *Regulatory and implementation aspects*

H. Forsström then invited the discussion to move to regulatory and implementation aspects.

Representing an organisation that produces nuclear waste, M. Thumann said that the challenge could be encapsulated in two statements – we do not need a final repository now, but we do need one

urgently – both statements are justified. In Switzerland, at present, there is only a small number of canisters of high-level waste and, allowing for storage and cooling, a repository will be needed in 2040 at the earliest. This does not matter – but we need something now to justify continued nuclear electricity production. In Switzerland, a majority may be in favour of new nuclear power in the light of environmental concerns and reducing reliance on imported gas, but the case will be stronger if clear steps have been taken along the waste management path. Another important issue, as a utility, is to know what the solution looks like and therefore how much it will cost. At present, in Switzerland, the funds set aside may be larger than needed and this acts against the economics of nuclear electricity. M. Thumann considered it was the duty of the regulators to explain to the public why it is acceptable to continue to produce nuclear waste.

J-P. Minon considered that there are three main elements – the rules, the regulator and the process. The fundamental rules – what is or not, what is “safe” – are socially determined. The rules need to be decided and understood at a national social level and they need to be clear and stable. The regulator needs to be strong, experienced and trusted – if the regulator gives permission to proceed, then this should assure society that it is safe to proceed. Thus, the regulator also needs the power to say no. The process must facilitate and allow the implementer, the regulator and the public to interact effectively. A procedure is needed to ensure progress and continuity of the dialogue – to put all the issues on the table and determine key issues. Complete and open documentation of the inputs, discussions and decisions is essential.

H. Issler noted that the goals should be set at the federal level. The way forward should then be specified in a roadmap with clear milestones. This must define the decisions to be made, when and by whom and the discussion needed for the decisions. Flexibility is important – keeping options open allows adaptation to new information and conditions. It would be reasonable to set milestones on the same timescale as political mandates so that a constant political review and endorsement or modification of the process is possible. All parties – politicians, implementers and regulators – must communicate that progress has been made and continues to be made.

B. McKirdy noted positive changes in the UK framework, particularly the move towards more active and early involvement of the regulatory body in the review of implementers’ proposals. For the implementer, this reduces project risk by receiving early input on the acceptability of proposals. It also positions the regulator as an authoritative, independent source of information to other stakeholders.

J. Laaksonen commented that it is not wise to keep all options open. It is important to make a decision in principle, with one concept in mind, and then pursue that path. The Finnish programme is now in the phase of a ten-year underground research programme leading to the development of a geological repository. The research may lead to modifications of the design and implementation, but the goal is clear. The regulator has important roles – to set safety requirements (for all times in the future) and to review the implementer’s research and engineering programmes, safety analyses and cost estimates. The regulator should also explain, to the policy makers and to the public, the need to decide on a final solution for nuclear waste and the means towards it.

H. Forsström asked whether the difference in view on flexibility (cf. H. Issler and J. Laaksonen) was related to stage in the programme. H. Issler replied that the Swiss have a specific goal of 2040 for a repository, but consider it good to keep flexibility for as long as possible within this time frame. M. Thumann commented that the important choice is where to build a repository. Nagra has established the regions in Switzerland where repositories could be safely developed, but time is needed for the public to follow the arguments and engage in the siting decision.

J. Laaksonen commented that it was a mistake to try to find the “best” place – in the Finnish case, the four sites investigated showed no differences in terms of safety and the choice was therefore

between sites that already hosted a nuclear plant and also favoured repository development. K. Riklin noted that, in Switzerland, the public generally agrees a repository is needed, but as soon as a location is suggested then the local public opposes it. One option could be to decide a long time in advance.

H. Forsström invited comments from the audience.

It was observed that the Swiss have a democratic culture that demands a choice. The process being followed aims to provide a choice between at least two sites. Switzerland is also different in having a very heterogeneous geology compared to Finland.

It was observed that Germany had found a site and “dug a hole” but were not in a position to implement a repository for political reasons. Scientists would like to complete the scientific and technical work, to produce safety and feasibility results and then give this information to the decision makers. Above all, political leadership is needed to take the process forward.

H. Forsström thanked the participants and handed over to Claes Thegerström and Werner Bühlmann to present their closing conclusions.

### **Closing statement**

The closing summary of the conference was presented jointly by Claes Thegerström of the Swedish Nuclear Fuel and Waste Management Company (SKB) and **Werner Bühlmann** of the Swiss Federal Office of Energy.

It is affirmed that there is *a common objective* to develop geological repositories. These must be based on sound science and high quality technology, provide safety, security and environmental protection and be both socially acceptable and economically feasible. They must also be developed by a transparent process within the national legal and societal framework.

The supporting conditions for this development are in place. There is a solid scientific and technical foundation – extensive R&D over more than 30 years, demonstrations of technology in hand and planned, safety assessment and modelling capabilities available and continuing national and international collaborative programmes. There is an established international framework of safety standards, recommendations and guidance (ICRP, IAEA, etc.) and international organisations (OECD/NEA, IAEA, EC, etc.) that provide peer review at different levels, evaluation of “state of the art”, fora for exchange of information and experience and co-ordination of efforts.

It should be noted, however, that the world is continually changing – not so much in science but to some extent in technology and certainly with respect to political and social expectations. The changes may be significant over the timescale of geological repository implementation. We should be open to future changes but must plan with what we have and what we know now.

This conference has illustrated that *a variety of paths* are being followed which relate to factors such as the motive and timing for geological disposal projects, national legal framework and national decision-making processes.

The motives for implementing repositories may be to deal with wastes from past and current nuclear power programmes (a practical need to deal with the liabilities), in view also of future nuclear power generation, an ethical view including sustainability and combinations of the above.

With regard to timing of implementation, some countries have chosen to implement disposal at the soonest practicable time, while others consider that disposal will be needed eventually but is not a current priority.

An overall legal framework is required, which defines the national process, the actors, their responsibilities and roles, milestones and timescales and financial conditions. This still leaves many questions open with respect to the consultation and decision-making process: How is the process designed (e.g. adaptive approaches)? How are conclusions drawn and decisions derived? To what extent can decisions be revisited? The consultation process may include consideration and choice among all long-term waste management options, or the decision to implement geological disposal may be taken directly by government or parliament.

When considering issues and priorities for siting, the focus may be on technical aspects of site selection (geological properties, land use planning, etc.) or on societal aspects (volunteer siting, regional or local decisions, etc.). The roles of nuclear municipalities must also be considered. In most cases siting will be based on an integration of all of the above issues.

Key issues in the process of developing geological repositories include the following:

- Trust must be developed (through credibility, integrity and accountability). Methods exist for promoting and maintaining these qualities. Trust takes a long time to build, but can be quickly lost.
- Communication is very important, to all stakeholders and appropriate to each stakeholder's needs.
- Openness and flexibility enable an implementer to develop a project considering the needs of the different stakeholders and to accommodate evolving expectations of society (energy policy, environmental concerns, etc).
- Time is needed to build relationships, to develop projects and to implement them (from technical and social perspectives).
- Maintaining the process over long times can be a difficult. The process must continue through relatively short-term political changes, working in the longer-term interests of the public and affected communities.

Decisions may be prepared and made at different levels. The national process should specify which decisions are to be made, by whom and on what basis. The regulator is responsible for ensuring a sound, safe and secure project. Decisions on national policy may be made by government or parliament, through national consultation or by referendum. Regional and state governments will be involved in decisions on siting within regions. Expectations of local host communities or municipalities may be paramount to implementation at a given site. It needs to be recognised that all levels and all stakeholders may contribute to the debate or consultation, but specific decisions necessarily lie with only a few actors who bear the legal responsibility.

Different paths are possible with respect to the regulatory system and its application. The approach may be prescriptive, with tight requirements on process and safety case, or permissive, making it the responsibility of implementer to propose a satisfactory option or case. Harmonised requirements that apply to all such major developments may be important. A key question is what licences are needed, when and based on what. A separate licence or formal permission to proceed might be required at each step, or a one-step approval might be given. In any case, ongoing or periodic review and updating of the terms of a licence are likely.

In conclusion, considering the progress that has been made since the last ICGR conference in 2003, the following points can be made. The need for deep geological disposal has been confirmed and reinforced. Steady progress is underway in many countries – programme decisions have been taken in several cases and there is additional experience of societal engagement. Difficulties exist and will continue to appear; these need to be handled. On a positive note, however, collective experience on the key elements needed for progress exists worldwide and this international experience can assist future developments in individual national programmes.

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## PROGRAMME

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**Monday 15 October 2007**      **Ensuring political and institutional legitimacy**

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### **Welcome address and introductory remarks**

Moritz Leuenberger, Federal Minister, Head of the Department of the Environment, Transport, Energy and Communications, Switzerland

### **Statement on behalf of the co-sponsors**

Luis Echávarri, Director-General, Nuclear Energy Agency of the Organisation for Economic Co-operation and Development

### **Session 1. Keynote addresses on strategic and policy developments**

- Introduction: Walter Steinmann, Director, Swiss Federal Office of Energy, Switzerland
- Claude Birraux, Member of the French National Assembly, First Deputy-Chairman of the Parliamentary Office for Scientific and Technological Assessment, France
- Greg Schulte, U.S. Ambassador and Permanent Representative to International Organisations in Vienna
- Luis Echávarri, Director-General, Nuclear Energy Agency of the Organisation for Economic Co-operation and Development
- Tomihiko Taniguchi, Deputy Director-General, Nuclear Safety and Security, International Atomic Energy Agency
- Zoran Stančič, Deputy Director-General, DG for Research, European Commission
- Torsten Carlsson, Chairman, Swedish National Council for Nuclear Waste, Sweden
- Kenji Ogiwara, Vice-Minister, Ministry of Economy, Trade and Industry, Japan
- Georg Arens, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany

### **Session 2. Panel-led discussion on strategic and policy experience**

Chair: Elizabeth Dowdeswell, Special Advisor to the Board, Nuclear Waste Management Organisation, Canada

#### **Panellists:**

- Volker Giraud, Head of the Section “Disposal and Decommissioning”, Ministry of the Environment of Baden-Württemberg, Germany
- Ute Blohm-Hieber, Head of the Unit for Nuclear Energy, Waste Management and Transport, Directorate-General for Energy and Transport, European Commission
- Hannes Germann, Member of the Council of States, Switzerland
- Kris Van Dijck, Member of the Flemish Parliament and Mayor of Dessel, Belgium
- Cyrille Vincent, Directorate-General for Energy and Raw Materials, Ministry for Ecology, Sustainable Development and Spatial Planning, France

## Closing remarks

Walter Steinmann, Director, Swiss Federal Office of Energy, Switzerland

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**Tuesday 16 October 2007      Ensuring protection, creating trust and bringing national projects forward**

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### Session 3. Societal aspects

Chair: Claude Birraux, Member of Parliament, First Vice-Chairman of the Parliamentary Office for Scientific and Technological Assessment, France

***Societal aspects and ethical issues***

Carl-Reinhold Bråkenhielm, Swedish National Council for Nuclear Waste, Sweden

***The experience of the NWMO in Canada***

Kathryn Shaver, Nuclear Waste Management Organisation, Canada

***Searching for a suitable site in Switzerland – The Deep Geological Repository Sectoral Plan***

Michael Aebersold, Swiss Federal Office of Energy, Switzerland

***Societal aspects in siting a radioactive waste disposal facility***

Jacob Spangenberg, Mayor of Östhammar, Sweden and Kaj Nilsson, Project Manager LKO (Competence building on nuclear waste issues in Oskarshamn municipality), Sweden

### Session 4. Implementation aspects

Chair: Luis Echávarri, Nuclear Energy Agency of the Organisation for Economic Co-operation and Development

***Overview of EDRAM and of the Canadian Nuclear Fuel Waste Management Programme***

Kenneth E. Nash, International Association for Environmentally Safe Disposal of Radioactive Materials and Nuclear Waste Management Organisation, Canada

***The implementation process for a deep geological repository for radioactive waste in France***

Marie-Claude Dupuis, National Radioactive Waste Management Agency, France

***Implementation of the Swedish concept of deep geological disposal***

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### Session 5. Regulatory aspects

Chair: Ulrich Schmocker, Swiss Federal Nuclear Safety Inspectorate, Switzerland

***The perspective of U.S. NRC***

Dale Klein, U.S. Nuclear Regulatory Commission, USA

***Regulatory aspects: The Finnish approach***

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***Radioactive waste disposal in Hungary from the regulator's viewpoint: Ensuring protection and creating trust***

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***The international approach to harmonise the requirements and the process for a geological repository***

André-Claude Lacoste, Nuclear Safety Authority, France

**Session 6. Panel-led discussion: Way forward – How can the political, societal, regulatory and implementation aspects be reconciled to a successful result**

Chair: Hans Forsström, International Atomic Energy Agency

**Panellists:**

- Carl-Reinhold Bråkenhielm, Swedish National Council for Nuclear Waste, Sweden
- Hans Issler, National Cooperative for the Disposal of Radioactive Waste, Switzerland
- Jukka Laaksonen, Radiation and Nuclear Safety Authority, Finland
- Jean-Paul Minon, Agency for Radioactive Waste and Enriched Fissile Materials, Belgium
- Kathy Riklin, Member of the National Council, Switzerland
- Manfred Thumann, Axpo Holding AG, Switzerland
- Bruce McKirdy, Nuclear Decommissioning Authority, United Kingdom

**Summary of the conference**

Werner Bühlmann, Swiss Federal Office of Energy, Switzerland

Claes Thegerström, Swedish Nuclear Fuel and Waste Management Company, Sweden

**Closing address**

Hans Issler, National Cooperative for the Disposal of Radioactive Waste, Switzerland



**CONTRIBUTED PAPERS**

## **Welcome Address and Introductory Remarks on Waste Management**

### **Moritz Leuenberger**

Federal Minister, Head of the Department of the Environment,  
Transport, Energy and Communication (DETEC), Switzerland

This conference is being held in the Paul Klee Centre. Although this is primarily a museum housing the works of Paul Klee, it is also an ideal location for an international conference on radioactive waste management, in the sense that the works of Paul Klee and radioactive waste have much in common. Both have an impact that will be felt over many generations to come.

There are other similarities:

Both have to be protected – the Klee paintings from thieves breaking in and the radioactivity from breaking out. Both therefore have to be stored securely.

Great significance is also assigned to the works of art and to the radioactive waste. There has been so much philosophising (including nonsense) about Klee's work that everyone wishes to be as close to it as possible – or, even better, to have a piece in one's own home. There has been so much debate about radioactive waste (also including nonsense) that no one wishes to have it anywhere near them.

The similarities do not end here. Whether we are talking about an art museum or a geological repository, both are special architectural undertakings and everyone wishes to have a say in how they are realised.

As experts, you have accepted technical responsibility for the safe disposal of radioactive waste. As citizens of your respective countries, you have also accepted responsibility by coming to this conference with the intention of exchanging views on political solutions to the waste management issue. I would like to thank you in particular for this willingness to enter into meaningful dialogue.

### **Responsibility**

There are opponents of nuclear power who, for tactical reasons, wish to hinder repository projects. In what they see as a legitimate – and I stress legitimate – fight against nuclear power, they seek to be able to argue that the issue of waste disposal has not been solved and that, as long as this is the case, no nuclear power plants should be constructed.

Even if the opponents themselves perceive their motives as being honest, the argument does not hold up under closer scrutiny and can even degenerate into dishonesty for the following reason.

Irrespective of whether we are for or against nuclear energy, irrespective of whether we use electricity from nuclear power plants or not, irrespective of whether we have at some time or another demonstrated for or against nuclear energy – we all bear responsibility for the safe disposal of radioactive waste. This is a reality. Today, we store the waste in surface facilities and we transport it across continents but, as yet, there are only a few safe deep geological repositories worldwide. It is exactly those who argue most strongly that man and the environment need to be protected from the effects of ionising radiation that have to be the most vehement supporters of deep geological disposal. Otherwise they are not being fair to their own descendants.

Of course we cannot account for everything that might happen in the future. But we do have a moral obligation to undertake everything in our power today, based on what we truly believe to be the best way forward.

Each of us is part of society and no one can free themselves of their responsibility towards those who have not yet been born but will one day inhabit this planet.

This duty is incumbent on those who, in the past, have fought against nuclear power, as it is on those who have never had anything to do with the construction of nuclear power plants – for example because they had not yet been born.

Our responsibility as members of the current society – a society whose decisions we may not always agree with or may even have fought against – still remains, because our duty towards others, including future generations, is more important than our personal views on the use of nuclear energy for peaceful purposes (using nuclear energy for military purposes is another matter). We cannot penalise others for our differences of opinion with political opponents.

What is decisive are the real hazards we face from waste that has not been safely disposed of. This is something we all have to deal with. Collective responsibility in this sense carries more weight than individual opinions and no one is free of this responsibility.

Such arguments are not easy to set up and it takes time to come to terms with them.

## **Time**

On the opposite side, in terms of politics, are those who wish to build repositories without delay. They trivialise the protests of the public and would like most of all to suspend all the rules of democratic interaction.

There are also tacticians in this group, whose main objective is to see that new nuclear power plants are constructed. This is as lacking in legitimacy as the delaying tactics employed by those who use the absence of a solution to the waste management issue to oppose nuclear power.

However, besides the tacticians, there are also those who are truly convinced that things could move faster.

They should think it over: as they say in Africa, pulling on the grass will not make it grow faster. All good things take time, as we say. Shakespeare said “Wisely and slow. They stumble that run fast.” Societal processes cannot be accelerated arbitrarily. What is true for one working team is also true for the greater picture: a group moves forward only as fast as its slowest member. This also applies to the search for repository sites.

Radioactive waste will remain hazardous for many generations. It takes time to find a suitable, safe solution. Time during which reservations can be expressed; time during which new technologies can be developed. Criticism often leads to important new realisations: would we have developed the principle of retrievability if it had not been for criticism on the part of the public of the lack of such a possibility?

All Swiss repository projects to date have been rejected by popular vote. You have probably had similar experience in your own country because this is not specific to Switzerland. For this reason, your focus at this conference is less on technical questions. You will be exchanging views and experience on the political and societal processes that are necessary if geological repositories are ever to be constructed.

The procedure that has now been proposed in Switzerland is called the sectoral plan for deep geological repositories. The main purpose of this is to create transparency and ensure participation – because we have always known that acceptance is essential to the success of a project. This is why we strive to achieve transparency:

- In formulating the criteria applying to potential sites.
- In the selection of such sites.
- In the selection procedure that we follow.

In Switzerland, we stand at the outset of this process. First, the rules we will apply in the site selection procedure have to be defined. This means firstly creating transparency and participation in the manner in which they should be created. The Federal Government will decide on this first step at the beginning of 2008. The entire process up to selection of a definitive site and an optional referendum on this decision is expected to last 7 to 10 years.

It may be that, on first impression, all these procedures aimed at ensuring transparency and participation seem to be somewhat long-winded, or perhaps even obtrusive, and 7 to 10 years may seem like a very long time. But we only have to think of other construction projects: football stadiums, an airport (or even a new runway for a small airfield), a motorway or a nature conservation area. None of these projects can be implemented without the understanding of the public and this often takes significantly longer than 10 years. Incidentally, for the Klee Centre, which was a private project and did not require to go to tender, it took 15 years before the doors were opened to the public.

This brings us back to the similarities. Behind the Klee Centre was the cultural will to construct the museum – behind geological repositories there is ecological conviction. These convictions must become reality, but this requires acceptance and time.

## **Statement on Behalf of the Co-sponsors**

**Luis Echávarri**

Director-General, Nuclear Energy Agency (NEA) of the  
Organisation for Economic Co-operation and Development (OECD)

Dialogue in society about managing radioactive waste typically stumbles over what might be called the “triple curse”: The material is waste, something which most of us have been taught to reject; the waste is radioactive and therefore mysterious – in that ionising radiation cannot be seen, smelled or touched – and dreadful or awesome – in that radiation is known to be able to both cause and cure cancer; most of the waste results from nuclear energy production, which, in some people’s eyes, may mean guilt by association. A fourth “curse” is also sometimes mentioned: radioactive waste can be associated with nuclear weapons.

Dealing with these aspects goes beyond the competence of the technical specialists. In hindsight, even if the level and time frame of protection that can be delivered by geological disposal systems is unparalleled and unprecedented, it is no surprise that progress in disposal has been hampered in the past by an overemphasis on the technical approach. Moving forward involves, yes, trust in the technical specialists but, more importantly, it necessitates environmental, educational and energy policies that allow the technical specialists to play their roles alongside other actors within a transparent decision-making context.

At one time, disposal was viewed as if it were a relatively short-lived activity to be completed in the time span of perhaps a single generation – the goal being to provide a facility that could safely contain radioactive waste without any further action or intervention by future generations. Increasingly, the implementation of a disposal project has come to be viewed as an incremental process, perhaps taking several decades to complete. This changing vision involves not only the concept of protection of future generations, but also incorporates the assumption that they will be involved in the process and that we need to preserve their ability to exercise choice. The last decade or so has seen an evolution in the roles and number of the various actors and, with that, a gradual shift in the complexity of the approach to implementation of a disposal facility.

Decision makers and opinion leaders, like you, are being called on to play an important role in moving this issue forward, including developing national strategies and plans where these do not currently exist and subsequently helping in their implementation, taking account of other related priorities, including environmental and energy policies and the need to observe the principle of sustainable development. Hence the value of a forum such as this conference where, through the exchange of information with other colleagues faced with a similar task worldwide, decision makers and opinion leaders can become better informed of progress to date, current debates and plans.

This conference is the third in a series that started in 1999 under the leadership of the then US Secretary of Energy, Bill Richardson. The second event took place in Stockholm in 2003. The common aim of these conferences is

- To take stock of political and strategic developments that have taken place in the field of geological disposal of radioactive waste worldwide.
- To facilitate information exchange and discussion amongst senior decision makers and opinion formers in this area.

The sponsors of the entire series of conferences have been EDRAM – the International Association for Environmentally Safe Disposal of Radioactive Materials – which is represented here by its Chairman Mr. Ken Nash, who is also President of Canada’s Nuclear Waste Management Organisation; the IAEA, represented here by Mr. Tomihiko Taniguchi, Deputy Director General for Nuclear Safety and Security; the European Commission, represented here by Mr. Zoran Stančić from DG Research and the Nuclear Energy Agency of the OECD that I represent. I would also like to thank the local organisers, Nagra, the Swiss National Cooperative for the Disposal of Radioactive Waste.

This conference witnesses the long-term commitment of our organisations to fostering the dialogue, at all levels, on the management and disposal of long-lived radioactive waste. As sponsors of this conference, we look forward to keeping the dialogue ongoing. As the decision-making process leading towards successful disposal will take decades to be completed, it behoves us to help maintain momentum and keep it on its course. It is a gauge of responsibility towards the present and future generations, to whom we wish to guarantee a safe, secure and sustainable future.

## The French Strategy for the Disposal of Radioactive Waste

**Claude Birraux**

Member of the French National Assembly,  
First Deputy-Chairman of the Parliamentary Office  
for Scientific and Technological Assessment, France

It is a great honour for me to open the session of presentations on national policies on the disposal of radioactive waste with the example of the strategy followed in France.

I feel this is a form of acknowledgement of France's relative lead in this field, but I hasten to add that the legitimate pride of being in such a situation is accompanied by a strong sense of responsibility, as this relative lead is to be interpreted in the light of two factors:

- First, it is not illogical that a country that ventured, thirty-five years ago, to launch the original approach of acquiring its energy independence by producing nuclear electricity finds itself in a position of having to devise a coherent radioactive waste management strategy slightly before other countries that took the same direction later, or with a lower level of intensity, for instance because they have other energy assets.
- Second, the French strategy has been inspired, in any case, by all the experiences from abroad, and continues to be applied in a scientific research perspective open to all international cooperation. To say that France is in a lead position is not therefore to claim that it can give lessons, but that it wishes to let others know about its experience and to benefit in return from all the solutions that could be proposed elsewhere.

I will present the French situation as a representative of the French Parliament and, more specifically, as a member of the Parliamentary Office for Science and Technology Assessment (*Office parlementaire pour l'évaluation des choix scientifiques et technologiques* – OPECST). This situation is quite symbolic of the essential mediatory role played by the French Parliament in France: at the end of the 1980s, the Government authorised an exploration campaign to find a geological area suitable for the deep disposal of wastes. The French population reacted rather violently to this initiative, feeling left on the margins.

The Prime Minister at the time, Michel Rocard, put an end to the exploration campaign and left it to Parliament to start in-depth consultations to clarify the situation. The result was that the member Christian Bataille was given the task, on behalf of the Parliamentary Office for Science and Technology Assessment, of submitting, in 1990, a report on the radioactive waste management strategy. A little later, the Act of 30 December 1991 defined the research avenues in this field for a fifteen year period.

In France, parliamentary intervention, as an expression of representative democracy, therefore gave rise to one of the fundamental means of taking into account the societal dimension of the radioactive waste disposal issue. I will return to this point later.

I would like to finish these preliminary remarks by congratulating Nagra for having organised this conference at a time of renewed international interest in the production of nuclear electricity. Such an approach is doubly relevant:

- First, it is essential to emphasise that the establishment of the nuclear electricity production industry must also comprise a waste management structure at the back end. It is important to

show that, in this field, contrary to what some opponents claim, operational solutions do exist, even if it is still useful to pursue research and exchange information internationally to improve these solutions.

- Then, it is of course necessary that the solution chosen in each country must be related to its production of radioactive waste. Indeed, while knowledge and experience can be exchanged across borders, there are obvious limitations to the international circulation of radioactive wastes. In France, the Act of 28 June 2006 recalled the ban on disposal of radioactive wastes from abroad. Cooperation between countries consists of mutually helping one another to find viable and responsible solutions, but in each of our territories.

Now that these fundamental points have been made, I propose to present the French approach to the geological disposal of radioactive waste on the basis of three key concepts:

1. Geological disposal must fit into a broader strategy of radioactive waste management, allowing the volume and activity of the wastes to be reduced and leaving the door open to possible future alternative technical solutions.
2. The credibility of the strategy followed is based at the same time on strong anchoring in scientific research, the publication of a clear implementation schedule and strict compliance with deadlines.
3. Social acceptability of the approach requires a very broad decision-making process mobilising all the resources of representative democracy, consultative democracy and contributory democracy.

**Geological disposal must fit into a broader strategy of radioactive waste management, allowing the volume and activity of the wastes to be reduced and leaving the door open to possible future alternative technical solutions**

To begin with, I would like to demonstrate that, to be fully effective, geological disposal must fit into the framework of a broader strategy, integrating other waste management instruments and, above all, a strategy open to long-term technical evolution.

In effect, the implementation of future solutions that could arise from scientific progress difficult to foresee today must not be compromised by overly rigid present-day approaches.

The concern over having to set in place solutions that are viable in the medium term must not prevent us from believing in the fecundity of science.

***The waste management strategy must reduce waste volumes and activity***

*Treatment and reprocessing decrease the final volume of wastes*

The French waste disposal strategy integrates the prime need to reduce waste volumes and activity. Treatment-recycling is already operational today and allows the final volume of wastes to be reduced.

In France, spent nuclear fuel is reprocessed to recycle the reusable materials not consumed in the reactor. On leaving an EDF pressurised water reactor, spent uranium oxide fuel retains a large part of its unburned energy materials: 93% uranium-238, 2% uranium-235 and 1% plutonium.

Using treatment techniques for these fuels, and especially separation of the various components, 96% of spent fuel can be recycled:

- Part of the treated uranium is re-enriched and recycled in the form of fuel for the nuclear reactors at the Cruas power plant.



- Plutonium is recycled into MOX fuel (mixed oxides of uranium and plutonium), currently used by 20 out of 59 reactors in France.

Treatment-recycling therefore facilitates radioactive waste management.

With respect to the disposal of spent fuel, it involves separating non-reusable radioactive wastes from the other components, which reduces the volume of wastes by a factor of 5.

Another advantage of treatment-recycling is that, by recovering and recycling uranium and plutonium that are responsible for a large component of the long-term radiotoxicity, it reduces the radiotoxicity of the wastes by a factor of 10.

All in all, the treatment cycle, which covers 1200 tons of fuel per year, leads to production of high-activity long-lived wastes with a volume of 110 cubic metres per year.

The stored volume in 2007 is around 2000 cubic metres, in other words a pool 100 metres long, 20 metres wide and a metre deep. It is as if, every year, this pool grew wider by one metre.

*The aim of partitioning and transmutation is to decrease activity*

The complementary prerequisite applying to the disposal of wastes, besides reducing their volume, is to reduce their activity.

This reduction of the activity of wastes is at the heart of research on partitioning and transmutation, which forms the number 1 strand of the waste management strategy followed in France since 1991.

The **separation** of minor actinides (neptunium, americium, curium) has been demonstrated in the laboratory. Various long-lived fission products have also been separated (particularly iodine and caesium).

Separation on an industrial scale depends on the refurbishment of the La Hague reprocessing facilities in 2040.

The feasibility of **transmutation** has been demonstrated by the experiments carried out with the Phénix fast reactor and transmutation performed in a pressurised water reactor.

To perform transmutation industrially, it will be necessary to have Generation IV fast reactors and/or accelerator-driven sub-critical (ADS) reactors.

These reactors are presently only in the conceptual stage. Their industrial start-up will take place around 2035. Taking into account the tests to be performed on their capacity to transmute large quantities of minor actinides, industrial scale transmutation should be operational in 2040 at the earliest.

After 2040, partitioning and transmutation should therefore allow the production of high-activity long-lived wastes to be limited:

- Second generation power stations, as it so happens, will reach the end of their lifetime around 2040.
- Third generation PWR plants will operate and produce active wastes until the end of the 21<sup>st</sup> century.
- Transmutation will leave only wastes in the form of minor actinides with half-lives of less than a thousand years.

Thanks to “treatment-recycling” and partitioning and transmutation, the issue of geological disposal is therefore very significantly downscaled.

***Disposal must be devised as an element of an evolving strategy***

*France has made the choice of reversibility*

Deep geological disposal obviously forms a strand of the French high-level waste management strategy. But France has integrated this into an evolving perspective, by highlighting the reversibility dimension.

As you know, the aim of disposal is to make an underground rock formation such as clay, granite, salt or tuff play the role of a “safe” for radioactive wastes.

The location of such a disposal site obviously raises the issue of **geographical choice**, since a suitable geological formation must be found: **I will return to this point**. But it also raises the issue of strategic positioning regarding the possible choice of **reversibility**.

France set itself a fifteen year period for research on reversibility or irreversibility. This was one of the major challenges of the Act of 30 December 1991 on research on radioactive waste management. It finally opted in 2006 for reversibility and this definitive decision is embodied in law.

In effect, engineering studies have demonstrated that a reversible disposal centre can be designed where waste packages can be recovered over a long period.

Reversibility allows a long waiting period to be integrated pending an **economically viable** scientific solution for eliminating high-activity wastes kept in the underground facility.

*Storage is an essential complementary strategy to disposal*

The French waste management strategy also considers long-term storage. The research conducted since 1992 has demonstrated that partitioning and transmutation, deep geological disposal and long-term storage are three management methods for high-activity, long-lived radioactive wastes that are **not competing**, but, on the contrary, are **complementary** per se and over time.

Therefore, long-term storage is essential to:

- Manage presently non-reprocessed spent fuel.
- Allow flexibility in management and a choice between transmutation and reversible disposal.

Furthermore, if, in the future, the reversibility of disposal actions becomes possible, it will certainly be necessary to make use of interim storage for packages awaiting reprocessing.

**The credibility of the strategy is based on strong anchoring in scientific research, publication of a clear implementation schedule and strict compliance with deadlines**

I will now analyse how the strategy followed by France is credible through being based on two pillars:

- Strong anchoring in scientific research.
- Strict compliance with planned deadlines, as demonstrated by the completed fifteen year stage from the 1991 Act to the 2006 Act.

There is admittedly almost a paradox in wanting to combine scientific research and strict deadlines, since researchers are rather accustomed to operating with no set dates. But maintaining a highly time-framed approach is essential for the credibility of the strategy.

### ***Strong anchoring of the strategy in scientific research***

#### *Scientific goals set by the 1991 Act*

The strands of the French strategy, as already mentioned, are in fact research strands: we saw that for the issue of reversibility or irreversibility.

Research pathways were listed by the Act of 30 December 1991 as 3 strands: strand 1 on partitioning and transmutation, strand 2 on deep geological disposal and strand 3 on long-term conditioning and long-term storage.

One of the contributions of the Act of 28 June 2006 is to have broadened the field of research, as the 1991 Act applied to high-activity, long-lived radioactive wastes and the 2006 Act applies to other categories of radioactive wastes. However, the Act of 28 June 2006 has embodied the anchoring of the French strategy around the same three research strands.

These Acts make any decision subject to scientific advances. For instance, the 1991 Act stated: *“before 30 December 2006, the Government will send Parliament a global report evaluating this research, accompanied by a bill authorising, where applicable, the set-up of a centre for the disposal of high-level long-lived radioactive wastes and setting the system of easements and constraints relating to this centre.”*

#### *The National Assessment Board (CNE) and monitoring by OPECST*

To follow up research, a specific body was set up by the 1991 Act: the “National Assessment Board”, tasked with producing an annual assessment report.

Its members, all acclaimed scientists or industrialists with great experience, are appointed half by the Government and half by Parliament.

After being set up, this Board provided full satisfaction with its 11 annual reports and its global assessment report at the end of the fifteen year research period that commenced in 1991.

The Board was re-formed by the 2006 Act, particularly to broaden the scope of its assessment work, and its renewal has been slightly accelerated so as to make it more concordant with research effectively conducted.

Persons from the ethical and political science fields have been appointed as members to extend its assessment capacity to research on the social acceptability of the radioactive waste management strategy.

Three international experts are also members, which illustrates France’s concern not to isolate itself, quite the contrary, from experience gained beyond its borders.

The Board’s work is assessed by the Parliamentary Office for Science and Technology Assessment, of which I have the honour of being a member, and for which I will have the opportunity to describe the important role in steering the French radioactive waste management strategy. This assessment takes the form of hearings following the submission of annual National Assessment Board reports.

The National Assessment Board, a scientific assessment body, is therefore placed, via the Parliamentary Office, under the scrutiny of Parliament.

### ***Strict compliance with a schedule***

#### *Deadlines laid down by the 2006 Act*

Fitting into the same scientific framework as that laid down by the 1991 Act, the 2006 Act on the sustainable management of radioactive wastes and materials took note of the research results obtained and set target dates for accomplishing the three research strands.

It should be noted that this approach followed the recommendations of the Parliamentary Office in its summary report of March 2005, and also that the adopted schedule is in keeping with that proposed by the Office.

#### **Referring to strand 1** on partitioning and transmutation:

- The 2006 Act states the need to have, by 2012, an assessment of the two possible reactor types for transmutation: accelerator driven sub-critical (ADS) reactors and 4<sup>th</sup> Generation reactors, especially fast reactors.
- The Act sets the date of 2020 for the start-up of a prototype 4<sup>th</sup> Generation reactor, in accordance with the Act of 13 July 2005 that sets energy policy guidelines and in compliance with the statement given by the President of the Republic on 5 January 2006.

#### **Referring to strand 2** on geological disposal, the 2006 Act:

- Limits studies to reversible deep disposal alone, as already presented.
- States, in addition, that studies must be finalised so that the application for a licence for a disposal site can be processed in 2015 and the facility put into operation in 2025.

**Referring to strand 3** on storage, the 2006 Act states that the modification of existing facilities, or the construction of new facilities, must be possible by the 2015 horizon.

#### *Scientific choices made since 1991*

The credibility of the strategy is based on the fact that the scientific objectives laid down by the 1991 Act have been achieved to date.

Referring to **strand 1**, we have already seen that partitioning and transmutation have been scientifically demonstrated.

Referring to **strand 2**, we have seen that the feasibility of reversibility is considered an acquired fact.

In addition, clay has been chosen as the most suitable formation for geological disposal in France. Granite has been ruled out owing to its propensity to fracturing, which would make it necessary to spread disposal over several dozen impermeable blocks.

Andra (the national radioactive waste management agency) has acquired many favourable results on the capacity of clay to confine radioactive wastes, thanks to its research conducted in the underground laboratories at Mol (Belgium) and Mont Terri (Switzerland) and also at Bure (Meuse), by drilling from the surface and by *in situ* studies in the chamber of the Meuse/Haute-Marne underground laboratory.

Bure Callovo-Oxfordian clay has favourable confinement properties, particularly because it has been demonstrated that the most mobile ions would not reach the top of the clay layer before 300 000 years.

Referring to **strand 3**, long-term conditioning and storage on the surface, these are two fields where major progress has been made.

1. The volumes of high- or medium-activity wastes have been reduced by a factor of 10 since 1992, particularly by the compacting of technological wastes and metallic fuel structures.
2. The durability of vitrified waste packages has been increased to over a hundred or so thousand years,
3. Long-term storage techniques on the surface or sub-surface, designed to extend the present industrial storage with a lifespan of 50 years, already guarantee lifespans of around a century.

This is a map showing the Bure underground laboratory, at the boundary between the Meuse and Haute-Marne departments, some 230 kilometres in a straight line from Paris and approximately the same distance from Berne.

Here is a plan showing a geological cross-section of the Callovo-Oxfordian *safe* at Bure.

Insofar as the choice of the Callovo-Oxfordian formation is an established fact, reconnaissance is now aimed at identifying a 30 sq. km. zone within the possible 250 sq. km. zone delimited by the regional tectonic structures and the hydrogeological conditions. This stage should be completed in 2009.

A second stage, from 2009 to 2012, will lead to the choice, within the restricted zone, of one or several zones suitable for the disposal site.

**Social acceptability of the approach requires a very broad decision-making process mobilising all the resources of representative democracy, consultative democracy and contributory democracy.**

This last part explains the conditions of the social acceptability of the strategy.

In this field, the aim is to combine the need to reconcile the coherence of the approach, which assumes a certain unity of decision in the Government and Parliament, with open dialogue with the population, and especially with the inhabitants of the zones concerned.

The aim is to obtain the broadest possible comprehension of the strategy followed so as to promote a climate of confidence. In this respect, an essential aspect is the commitment of Parliament, and more specifically of the Parliamentary Office for Science and Technology Assessment, regarding the definition of goals and concerning the follow-up of implementation.

Alongside representative democracy, great emphasis must of course be placed on consultative democracy and also on what can be called contributory democracy, in other words directing of public financial means towards the zones most directly concerned in the name of national cohesion.

### ***The mainstay of representative democracy***

#### *OPECST's pivotal role*

Parliament's involvement in the management of radioactive wastes mainly entails the preparation and follow-up work of the Parliamentary Office for Science and Technology Assessment, even if debates on bills form high points of the roll-out of the strategy.

The Office first became acquainted with the issue of radioactive wastes on the occasion of the first report by Christian Bataille in December 1990. This report presented a set of measures for taking a fresh look at the way of tackling this issue, which was in a situation of deadlock at the time. These measures then formed the structure for the Act of 30 December 1991.

Afterwards, the Office gave special attention to following up the developments and research, producing six reports:

- 1992: Report on low-level radioactive wastes, by Jean-Yves Le Deaut.
- 1996: Report on research on high-level radioactive wastes: civil wastes, by Christian Bataille.
- 1997: Report on research on high-level radioactive wastes: military wastes, by Christian Bataille.
- 1999: Report on the back-end of the nuclear fuel cycle, by Robert Galley and Christian Bataille.
- 2000: Report on the impact of radioactive waste disposal facilities on public health and the environment, by Mme Michèle Rivasi.
- 2001: Possibilities of long-term storage of irradiated fuel, by Christian Bataille.

The report of 15 March 2005 by Christian Bataille and myself was the Office's eighth report on radioactive wastes.

This report answered a referral to the National Assembly Bureau by the four political groups represented in Parliament – UMP, PS, UDF and PC – which emphasised the broad political support enjoyed by the approach followed since 1991, and also the confidence granted to the Office.

The report title summarised the entire situation: “Looking after the longer term: a bill in 2006 on the sustainable management of radioactive wastes.”

“Looking after the longer term”: This expression recalls that the energy policy time horizon is long term. It also recalls that nuclear power is an industry of long time periods: for the management of wastes and also for investment in the production tools and in the fuel cycle management system.

“A bill in 2006”: the 1991 Act had set a deadline after 15 years of research on the three strands; the aim was to take decisions on the three research strands and deal with their interconnection over time.

“Sustainable management of radioactive wastes”: it was necessary to integrate into the strategy the idea of technological progress promised by the pursuit of the research effort. It was also necessary to obtain support from citizens, especially those living in the regions directly concerned.

A few words of presentation on the Office: the Parliamentary Office is a permanent delegation, jointly operated by the National Assembly and the Senate, where parliamentarians from each assembly sit. The Office comprises 18 deputies and 18 senators appointed by their political party, the number of representatives of each party being proportional to their strength in each assembly.

The Parliamentary Office can have recourse, as and when required, to the competences of the members of a scientific board composed of 24 members.

The authorities of the Assemblies refer scientific or technological issues to the Parliamentary Office.

It is set up to address topics in a long-term perspective in a manner allowing broad political support, if not consensus, to be obtained.

The preparation of the March 2005 report was a perfect example of the way in which the Office works, since it was drafted on the basis of a very broad consultation:

Missions were conducted in seven countries: Belgium, Finland, France, Germany, Sweden, Switzerland and the United States – 180 persons were met on the spot. In France, 70 persons were met in research centres and facilities, or through private hearings. The rapporteurs met the elected representatives concerned in the Haute-Marne, Meuse and the Champagne-Ardenne and Lorraine regions.

#### *Importance assigned to parliamentary decisions*

Parliament intervened directly, as such, when the two Acts of 1991 and 2006 were passed, but it is laid down that it shall also be involved in the procedure to process the authorisation licence to build a disposal centre.

In effect, this procedure provides for:

- A report by the Parliamentary Office.
- Above all, the passing of a bill laying down the conditions of reversibility.

The start-up of the underground laboratory cannot take place without a further parliamentary decision.

#### *Place given to consultative democracy*

Consultative democracy takes two forms:

- Use of broad prior consultation.
- Participation in follow-up and disclosure bodies.

#### *Prior consultation*

Prior consultation takes place at two levels in the procedure to process the authorisation license to build a disposal centre:

- On the occasion of a prior public debate.
- During the public inquiry preparing the State Council decree.

#### *Information and follow-up bodies*

At least three disclosure and follow-up bodies address the start-up of the disposal site:

- The local disclosure and follow-up committee (CLIS) created specifically by the 1991 Act to accompany the setting in place of an underground laboratory.
- The local disclosure committee (CLI), a local body which must automatically be created around any basic nuclear facility, and therefore around a disposal centre, pursuant to the Act of 13 June 2006 on transparency and safety in the nuclear field.
- The high committee for transparency and information on nuclear safety (HCTISN), a national body set up by the same Act of 13 June 2006 and tasked by the Act of 28 June 2006 with periodically organising consultations and debates on the sustainable management of radioactive wastes and materials.

## ***Supporting local development***

### *Assignment of specific resources*

On Parliament's initiative, local development and scientific and technological development of the territories where underground laboratories are sited receive specific support through public interest groups set up in each department concerned.

This support is based on specific resources, thanks to:

- The creation of an accompanying tax paid by nuclear operators.
- The creation of a technological dissemination tax also paid by nuclear operators.
- The obligation to produce specific results imposed on nuclear operators for their participation in local economic or scientific development. They must demonstrate this in an annual report.

### *Intervention on quite a broad front*

Specific support is organised, via Public Interest Groups, to promote local development and scientific and technological development in the regions concerned.

The 2006 Act also provides for support in the dissemination of scientific and technological knowledge, which takes on specific symbolic importance since it underscores the inclusion of the radioactive waste management strategy in a scientific research effort.

A decree of February 2007 defined the beneficiary zone that is called the "proximity zone" in a quite generous manner that covers the surrounding districts which are often quite small: Bure itself, at the centre of the site, has a population of less than 100 inhabitants.



## **The Global Nuclear Energy Partnership and Our Shared Nuclear Future**

**Ambassador Gregory L. Schulte**

U.S. Permanent Representative to the United Nations Office in Vienna  
and the International Atomic Energy Agency

Ladies and gentlemen, it is a pleasure for me to take part in this third international conference on geological disposal of radioactive waste.

I would also like to extend greetings on behalf of the U.S. Energy Secretary Samuel Bodman. He appreciates the sustained international dialogue on geological disposal since it was first suggested by the Department of Energy at the IAEA 1998 General Conference.

In 1999, the first international conference on geological repositories concluded that:

No matter which fuel cycle is chosen or what the future holds for nuclear power, geological repositories will be an essential part of the waste management systems.

Since then, the expanded use of nuclear power in the U.S. and elsewhere has grown more likely. Already, license renewals have been granted for almost half of all U.S. reactors and renewal applications have been filed or planned for 27 more. Even more telling, just three weeks ago a U.S. utility filed the first license application for new construction in 33 years. The Nuclear Regulatory Commission expects as many as 30 such applications.

Because nuclear energy does not emit greenhouse gases, many countries are exploring the option of nuclear power to meet energy demands. At last month's Major Economies Meeting on Energy Security and Climate Change, President Bush pointed to nuclear power as "the one existing source of energy that can generate massive amounts of electricity without causing any air pollution or greenhouse gas emissions."

Geological repositories are important – this international dialogue is important – because solving the waste problem is key to the continued use and expansion of nuclear power. Nuclear power is the only mature, emissions-free technology that can supply the necessary power to meet the projected increase in demand for electricity.

On the other hand, it carries the proliferation risks of the nuclear fuel cycle. To address both the promise and the risk of nuclear energy, the U.S. launched the Global Nuclear Energy Partnership, GNEP, to develop alternatives to sensitive fuel cycle technologies. GNEP will develop advanced technologies that will maximise the energy derived from the uranium dug out of the ground, minimise the risk of nuclear proliferation and reduce the volume of waste destined for long-term storage.

I am pleased to report that GNEP membership recently tripled in size to 16 countries at its second meeting on 16 September. The meeting was attended by representatives of 35 nations and three international organisations. These countries represented every region around the world and every stage of nuclear power development. The ministerial participants discussed a vision for the future of clean, safe, affordable, secure nuclear energy that does not contribute to proliferation.

GNEP seeks viable alternatives to sensitive fuel cycle technologies. Several proposals have been presented at the IAEA that would provide reliable access to nuclear power reactor fuel as a back up to

the commercial market. We hope the IAEA Board of Governors will be able to make a decision on these concepts in the next year. GNEP also envisions fuel leasing and spent fuel take-back mechanisms in the future.

The United States is working through GNEP with other nations to develop and deploy advanced reactors that consume transuranic elements. Through GNEP, partner countries are developing technologies for recycling spent nuclear fuel that do not separate plutonium. It is envisioned that such advanced fuel cycle technologies will reduce the quantity of nuclear waste, simplify its disposal and extend the capacity of geological repositories. The need for repositories will not go away. But they may not fill as quickly and the waste in them may not be as radioactive for as long.

Conferences like this one can help to refute the canard, often repeated by opponents of nuclear power, that “no one knows what to do about the waste.”

Science will enable the technological advances that lie behind GNEP. Science also underpins the broad international consensus that geological disposal is a feasible and safe way to dispose of high-level radioactive waste. That consensus was reaffirmed in a 2000 study by the U.S. National Academy of Sciences, which was supported by nine countries. After studying a range of alternatives, the Committee stated that:

After four decades of study, geological disposal remains **the only scientifically and technically credible long-term solution available** to meet the need for safety without reliance on active management. It also offers security benefits because it would place fissile materials out of reach of all but the most sophisticated weapons builders.

The second International Conference on Geological Repositories, held in Stockholm in 2003, found “that technological aspects of geological disposal can be considered to have been solved. Although further progress will surely be made, no major breakthrough is expected in this area and many consider the technology to be mature.”

In the U.S., we are making progress towards our own geological repository. In 2002, the President approved the Yucca Mountain site. This action – supported by bipartisan majorities in both Houses of Congress – was a critical step in a decision process laid out in our 1982 Nuclear Waste Policy Act. The next step is for the Department of Energy to submit a license application to the Nuclear Regulatory Commission. As you will hear in more detail tomorrow from the DOE’s Director of the Office of Civilian Radioactive Waste Management, Ward Sproat, the DOE is on track to submit that license application no later than June 30th of next year.

The U.S. is committed to making nuclear power more widely available. It is also committed to solving the challenge of safe radioactive waste disposal by the development of a permanent repository. A geological repository is needed under any fuel cycle scenario. We believe that the technology development and demonstration of a closed fuel cycle, as envisioned in GNEP, and licensing and development of the Yucca Mountain repository are compatible and mutually supportive.

We believe that a geological repository is vital to the management of nuclear waste from current nuclear energy production and also to the successful expansion of nuclear energy in the United States.

The theme of this conference is “A common objective, a variety of paths.” It is clear that different nations have different needs and considerations with respect to repositories. However, it is also clear that a worldwide consensus on the technical, regulatory and political issues of permanent disposal is emerging.

Through GNEP, we envision a world in which nuclear power is a leading source of energy and available to more states worldwide. GNEP partners are committed to promoting nuclear energy as a clean source of power, reducing proliferation risks and addressing nuclear waste burdens.

We also envision approaches to the fuel cycle that offer significant non-proliferation advantages by ending the production of separated plutonium, drawing down inventories of plutonium and spent fuel and assuring reliable fuel services, while extracting greater energy value. We invite other states who share this vision to join us in adopting these principles and moving forward to expand the civil use of nuclear power.

No single state can deal effectively on its own with the challenges of energy, proliferation and waste management that face the world. Energy markets are global, as are the consequences of our energy choices. Enduring solutions will require common approaches, shared aims, cooperation and consistent effort.

## **Geological Disposal: Key Observations and Lessons Learnt – the NEA Perspective**

**Luis Echávarri**

Director-General, Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD)

### **Introduction**

The Nuclear Energy Agency (NEA) is a specialised agency of the Organisation for Economic Co-operation and Development (OECD). As part of our mission to our 28 member countries, we help maintain and further develop, through international co-operation, the scientific, technological and legal bases required for safe, environmentally friendly and economical use of nuclear energy for peaceful purposes. We also provide authoritative assessments, and help forge common understandings on key issues, in order to inform both our member governments' deliberations on nuclear energy policy and the broader OECD policy analyses in such areas as energy and sustainable development.

We have been, and still are, a leading organisation in the field of radioactive waste management and, in particular, geological disposal. Our activities cover policy, regulatory, technical and public involvement aspects of geological disposal. We have helped the field move forward through joint pioneering projects such as the Stripa project in the 80s, as well as through regulatory and policy reflection. We have developed what is today the reference approach to producing a disposal safety case.

Our first major report dates from 30 years ago, when we issued the so-called "Polvani report" of September 1977 on "Objectives, concepts and strategies for the management of radioactive waste arising from nuclear power programmes." Since then a lot has been learned. A list of recent NEA documents dealing with radioactive waste management is provided with the documentation for this conference. In the rest of the paper, we offer an overview on the key observations and lessons learned since our pioneering "Polvani report".

### **Key observations and lessons learned**

#### ***Why geological disposal?***

Whatever the future of nuclear power, it is generally recognised that safe and acceptable disposal solutions for existing and future long-lived and high-activity waste must be pursued. There are no miracle solutions: physical transmutation of some of the waste or advanced fuel cycles will not eliminate the need for disposal. Besides, long-lived and high-activity radioactive wastes are also generated from non-power applications of nuclear materials and isotopes, such as in medicine, industry and research.

Mature and safe methods for the management of radioactive waste are currently available and are being implemented. Society, as an extra precaution, has determined that some long-lived wastes, including high-level radioactive waste and spent fuel, should be disposed of such that they are contained and isolated from humans and the accessible environment without the need for continued human intervention.

International conventions prohibit disposal in the sea bed which, for all practical purposes, restricts disposal to land-accessible locations. Underground disposal is thus being investigated world wide as the ultimate waste management end-point. The concept anticipates that any releases are small both relative to the overall inventory of waste and in absolute terms, and that these proportionately small releases migrate very slowly, resulting in additional decay and, at most, in negligible incremental radiological impact over background radiation.

The level and time frame of protection that are demanded – and can be provided – by a geological disposal system are unprecedented when compared to other practicable options, including those in common use for many non-radioactive but hazardous wastes. The placement of these wastes deep underground, in a robust engineered system matched to a suitable geological setting, is thus felt to afford appropriate protection for the present and future generations.

The geological disposal concept, including its safety and ethical implications, has been debated in national legislatures, in state, provincial and local discussions, by individuals, in peer reviewed literature, in international organisations and by national scientific bodies. This demonstrates a general consensus on the geological disposal option, achieved through a broad societal process.

Delaying work on geological disposal – i.e. by adopting a wait and see strategy – requires continuing and more and more demanding care, which cannot be guaranteed. A long-term management option without a definite end-point is thus not only unacceptable ethically, but it is also potentially unsafe. Against this background, most countries have inscribed geological disposal in their policy objectives.

### ***Where do we stand with geological disposal?***

Since the Stockholm Conference of December 2003, important milestones in geological disposal have been reached in a number of OECD countries. Namely, having taken into account important public and stakeholder involvement, final isolation in geologic facilities is now the recognised reference solution also in Canada, France and the United Kingdom. In France, a siting region has been identified for all high-activity and long-lived waste; in Canada, a deep repository is being constructed for operational waste, while a process will be defined for siting a geologic repository for used nuclear fuel. The United Kingdom is now reflecting on how to set up a decision-making process that would associate local communities in the identification of a geological disposal site for radioactive waste.

In the meantime, other OECD countries who had already committed themselves to geological disposal have also reached important milestones. In Finland and the United States, a site and a design have been identified and work is ongoing towards the development of a repository. In Sweden, two localities have been identified and are now being investigated for the siting of a deep repository. In Switzerland, after the promulgation of the new Nuclear Energy Act, a plan has been drafted and is being implemented to search for repository sites. In Germany, a licence has been granted to operate the deep repository at Konrad for “non-heat emitting wastes”, which include waste with long-lived components. Finally, it is worth remembering that the WIPP deep repository for transuranic waste continues successful operation in the United States.

### ***Geological disposal is technically feasible***

Central to successfully implementing geological disposal is the ability to demonstrate and communicate the safety and security of the repository system far into the future in a manner that is clear, scientifically sound and persuasive to decision makers and the public.

There is now a wide consensus on the general approach for the technical safety assessment for geological disposal and many examples exist of recent successful use of safety cases for national decision making. Switzerland (2006) and France (2006) constitute the most recent examples. Exchanging information and working co-operatively under the aegis of international organisations such as the International Atomic Energy Agency of the United Nations and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development have been important factors in this progress.

OCED/NEA peer reviews have proven to be significant contributors to improving safety cases and to final decisions in moving national programmes to the next stage. The latter has been, for instance, the case in France, Japan, Switzerland and the United States. The two peer reviews we ran in the USA were co-organised with the IAEA.

The deep disposal concept relies on the capabilities of both engineered barriers and the local geology to fulfil specific safety functions, either in a complementary or in a redundant fashion. A large experimental data base regarding sites and materials has been accumulating, there is an improved understanding of processes at various spatial and temporal scales and significant advances in modelling techniques have been achieved. There also exist several underground research, demonstration and/or development facilities. Overall, it is felt by the experts, as well as by the non-specialist public that has been most exposed to the work, that sufficient evidence exists to suggest that geological disposal is a technically achievable solution.

### ***Some broader challenges in practical implementation***

We are now facing the challenge of practical implementation of geological disposal through further development and licensing. From a regulatory point of view, the ICRP recommendations (especially those on disposal), the IAEA Safety Fundamentals and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management provide a framework of common objectives to guide this implementation. This international framework provides goals and objectives for achieving an appropriate level of protection, including such elements as requiring a suitable regulatory framework, applying a stepwise approach in decision making and protecting future generations without imposing undue burdens.

Although countries are implementing the international framework and pursuing common safety objectives, every country is at a different juncture in the process and has different needs. Some countries have found it essential to reflect unique repository attributes in the selection of repository performance criteria.

Regulators, implementers and policy makers have become more aware that confidence of the technical community in the safety of geological disposal is, by itself, not enough to gain public confidence and acceptance. There is now agreement that a broadly accepted national strategy is required to provide not only the means to build the facility but also a framework and roadmap to provide both decision makers and the affected public with the time and means to develop sufficient confidence in the various decisions at hand and, ultimately, in the achieved level of long-term protection. A first step in the strategy is the definition of a national energy policy which addresses the role of nuclear power and in which the waste arisings are recognised. The issuance of a national plan with indications for the final management of all types of radioactive wastes is an important addition and basis for discussion and public acceptance.

Very importantly, the international framework – as embodied, for instance, in the Aarhus and Espoo conventions – also requires public information and stakeholder involvement, both nationally and across borders. Similar requirements are reflected in national laws, e.g. those concerning transparency in decision making and those requiring environmental impact studies.

The legitimacy of the process is paramount: national policy and legislating bodies must put it in place and provide means to follow it on. The quality of the process is also paramount: (a) roles must be clear; (b) there should be adherence to both one's own roles and to the rules of the process; (c) all participants in the process must behave and be viewed as trustworthy and accountable.

There has been an important evolution in the expected roles of the various actors over time (see Table 1). Regulators, for instance, are increasingly requested to be, by the public, the “people’s expert”. A capital role in the new decision-making environment is being played by the host communities. These are increasingly becoming partners in negotiating for locally acceptable solutions that minimise negative impacts and provide for local development, local control, partnership and, ultimately, a durable relationship between the facility and the community.

Table 1. **Traditional and evolving roles and responsibilities**

<b>Stakeholders</b>	<b>Traditional roles and responsibilities</b>	<b>Evolving roles and responsibilities</b>
Policy makers	Defining policy options, investigating their consequences under different assumptions, making policy choices.	Informing and consulting stakeholders about policy options, assumptions, anticipated consequences, values and preferences. Setting the “ground rules” for the decision-making processes. Communicating the bases of policy decisions.
Regulators (policy makers in safety authorities)	Defining regulatory options, investigating their consequences under different assumptions, making choices regarding regulatory options.	Informing and consulting stakeholders about regulatory options, assumptions, anticipated consequences, values and preferences. Communicating the bases of regulatory decisions. Providing independent expertise for local communities.
Scientific experts, consultants	Providing qualified input for the decision-makers.	Providing balanced and qualified input for stakeholders and encouraging informed and comparative judgement. Acting as technical intermediaries between the general public and the decision-makers.
Implementers	Finding a solution for the radioactive waste management problem, implementing the solution.	Co-operating with local communities to find an acceptable solution for the radioactive waste management problem. Co-operating with local communities in implementing the solution.
Potential host communities	Accepting or rejecting the proposed facility.	Negotiating with implementers to find locally acceptable solutions for the radioactive waste management problem that minimise negative impacts and provide for local development, local control and partnership.
Elected local or regional representatives	Representing their constituencies in debates on radioactive waste management facilities.	Mediating between several levels of governments, institutions and local communities in seeking mutually acceptable solutions.
Waste generators	Providing (partial or full) finance for solving the radioactive waste management problem.	Providing finance for solving the radioactive waste management problem under transparent arrangements and demonstrating this transparency.

***A common objective, a variety of paths***

Culture, politics and history vary from country to country and provide different contexts for establishing and maintaining public confidence. What works in one country may not be as effective in

another. As a result of openness to different perspectives, there must be openness to nations reflecting individual cultural and societal values in their processes and regulatory criteria, which may result in similarities as well as differences among nations. For instance, what was expected to be a common regulatory approach and common safety criteria and time frame is now a more complex reflection of national and pan-national interests, local and regional cultural views and societal values. Differences in regulation and implementation may not only be appropriate, but may even be critical for public confidence and acceptance.

Cultural, societal and geographical similarities and differences have resulted in a variety of paths, but common safety and security objectives underlie these paths in national disposal solutions. We need a continued, shared understanding of how this progress is being achieved and how we might achieve the same objectives in our own country, but perhaps on a different path. International fora are important for identifying similarities and differences and for identifying overarching themes and lessons to be learned.

## **Conclusions**

At one time, disposal was viewed as if it were a relatively short-lived activity to be completed in the time span of perhaps a single generation – the goal being to provide a facility that could safely contain radioactive waste without any further action or intervention by future generations. Increasingly, the implementation of a disposal project has come to be viewed as an incremental process, perhaps taking several decades to complete. This changing vision involves not only the concept of protection of future generations, but also incorporates an assumption of their involvement in the process and a need to preserve their ability to exercise choice. The last decade or so has seen an evolution in the roles and number of the relevant actors and, with that, a gradual shift in the complexity of the approach to implementation of a disposal facility.

The success of this conference should be viewed as reaffirming the *common objective of safe geological disposal* and reinforcing the message that *continued attention by decision makers* is one important ingredient to keep on course a process that still will take decades to be completed.

Success should be viewed as reaching a common understanding that the *variety of paths represent complementary avenues*, which arise from modern, democratic, but nation-specific approaches to governance. Communication of this shared understanding by decision makers can have a significant impact on the confidence of all stakeholders.



## **The Safety of Geological Disposal – Convergence of International Perspective**

**Tomihiko Taniguchi**

Deputy Director-General, Nuclear Safety and Security,  
International Atomic Energy Agency (IAEA)

At a time when we are witnessing an expansion of nuclear power programmes to meet the increasing energy demands in many parts of the world, radioactive waste disposal continues to be high on the nuclear policy agenda of many countries. Together with the overall safety of nuclear power plants and decommissioning, waste disposal and, in particular, the safety of geological disposal remains a key concern of the public and the news media. The plans for new and reinvigorated nuclear power development worldwide need to be complemented by equally ambitious plans for the establishment and enhancement of sustainable radioactive waste management programmes encompassing all types of waste generated by the nuclear fuel cycle, up to and including their final disposal.

While considerable experience has been accrued in operating radioactive waste disposal facilities located in the near-surface environment, the geological disposal of high-level waste and spent fuel has yet to be demonstrated. Good progress is being made in a few countries, with the possibility to have operational facilities around 2020. In most countries with nuclear power programmes, however, programme schedules are slipping and little real progress towards the siting and development of disposal facilities is seen. This is a worrying development, particularly as an increasing number of countries announce their intention to introduce nuclear power.

The failure to properly address waste disposal in the first decades of nuclear energy development have left a legacy of doubt in the minds of the public and politicians over its overall safety. If this doubt is not ameliorated soon, it could well lead to all the ambitious plans to expand the use of nuclear power on a global scale being significantly delayed.

The last two decades have seen the principal elements of a global nuclear safety and security regime covering radioactive waste disposal develop and become established. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was negotiated and agreed in the late 1990s and is now in force, international safety standards are maturing and, together with national legislation and regulations, have already contributed significantly to improvements in the safety of radioactive waste management around the world.

The Contracting Parties to the Joint Convention have now held two review meetings. The meetings have identified areas where significant progress has been made, particularly in the establishment of holistic national waste management policies, including decommissioning activities, and in the management of legacy wastes. A number of challenges have been identified in the implementation of these policies, amongst which are the long-term management of spent fuel, the disposal of high-level waste and the need to find suitable disposal options for all types of radioactive waste. With respect to the latter, the IAEA convened an international workshop in July this year where the concept of a common framework linking all waste types with disposal options was discussed and where a convergence of ideas was evidenced. The waste types suitable for near-surface disposal and geological disposal were discussed, as was the potential utility of disposal at intermediate depths for waste that does not require the degree of containment and isolation afforded by geological disposal.

The role of international safety standards in improving safety worldwide and their utility has been significantly enhanced since the initial approval of a set of three Fundamental Safety Principles for

nuclear safety, radiation safety and radioactive waste safety by the IAEA Board of Governors in the mid 1990s. A consolidation of these principles into a single Safety Fundamentals document has recently been achieved, a development setting the scene for greater harmonisation of the approach to safety across the whole spectrum of nuclear- and radiation-related technologies. Safety Requirements documents covering all nuclear installations and other facilities and activities where radioactive materials are used or handled have since been developed and used by many countries in national legislation and regulatory processes.

The suite of documents within the Safety Standards Series devoted to radioactive waste management is now comprehensive. In particular, the Safety Requirement on the Geological Disposal of Radioactive Waste, published in 2006, represents a significant development in the substance, structure and style of IAEA safety standards and a model for future standards. In view of the increasing interest in the safety of geological disposal and the national sensitivities with respect to public and political acceptance, this standard was subject to intense scrutiny by all Member States of the IAEA and the NEA, who co-sponsored its development and approval. As such, it forms a substantial point of reference for safety demonstration. The requirements are set out in 23 discrete paragraphs which make use of the word *shall* in defining safety imperatives. The requirements are supported by explanatory text that elaborates on their de facto implications. A Safety Guide is in preparation to provide guidance on meeting the requirements consistent with prevailing best practice.

Concentrating and containing radioactive waste and isolating it from the biosphere is the accepted strategy for its management within the global nuclear safety and security regime developed and adopted by IAEA Member States. Disposal in stable geological formations several hundreds of metres underground is deemed to provide the necessary degree of containment and isolation for high-level waste and, as such, it is widely considered to be an appropriate method for the disposal of such waste. Good progress towards geological disposal has been made in the development of techniques for encapsulation of the waste, site investigation and characterisation, disposal facility excavation, waste package emplacement and development of buffer and backfill materials. Sophisticated modelling techniques have also been developed to assist in assessing the safety of geological disposal facilities, covering both the engineered and natural components of disposal systems.

Nevertheless, the key issue in all programmes concerned with disposal facility development and operation is the need to provide a convincing demonstration of their safety and security, particularly their long-term safety. Demonstrating that protection of the public and the environment has been adequately provided for over long timescales requires the behaviour of the disposal facility to be predicted and modelled into the distant future, a complex undertaking involving many processes and interactions within the disposal facility itself and its host geological environment. The modelling results have to be compared with radiation protection criteria, a process complicated by the range of values obtained when a multitude of possible scenario evolutions are computed. Different approaches to addressing these issues have been adopted in different countries and this remains an area where further harmonisation is foreseen.

The subject of such safety demonstration is clearly one where international harmonisation is essential, particularly in the light of ever increasing globalisation of technologies and information availability, a situation which clearly calls for further international cooperation. The recently published international safety standard, *Geological disposal of radioactive waste: Safety requirements*, provides an up-to-date point of reference for safety demonstration for geological disposal facilities and a sound basis for inter-comparison. It has been used recently by a group of European countries interested in developing a harmonised approach to safety demonstration of geological disposal within the European region. In view of, and complementary to, these developments, the IAEA has recently established an international project to work towards harmonisation of approaches worldwide to demonstrating the safety of geological disposal – the GEOSAF project.

The project will provide a global forum to examine the evolution of arguments, assessments and supporting evidence, developed to provide a reasonable level of assurance of the safety of geological disposal and will give particular attention to their systematic review by the regulatory body. The project will complement the experience gained in a number of similar international projects undertaken by the IAEA and the NEA and other authorities relating to safety demonstration. Both similarities and differences in approaches taken in different countries will be identified and the differences analysed in order to understand the reasons. Further dialogue and exchange will then take place with a view to understanding if the same end point is being achieved by the different approaches or if, in fact, a preferred approach can be identified.

Geological disposal of high-level waste not only provides a safe disposal environment, but also provides for a high level of physical security. The degree of containment and isolation associated with geological disposal largely precludes security concerns. Nevertheless, security provisions for transport to, and storage on, sites prior to disposal will require due attention. The amended *Convention on the Physical Protection of Nuclear Material* (CPPNM), when it has entered into force, sets requirements for states to implement physical protection measures not only for nuclear material in international transport but additionally for domestic transport and for facilities in which nuclear material is produced, processed, used, handled stored or disposed of. These measures should address proliferation concerns (theft) and sabotage leading to severe radiological consequences.

The more practical aspects of nuclear safeguards continue to be an issue of consideration for geological disposal of spent nuclear fuel. In 2006, the so-called ASTOR (*Application of Safeguards to Geological Repositories*) working group was established by the IAEA with the objective of developing new safeguard approaches for geological disposal facilities that are planned to be operational in the foreseeable future, such as the Finnish facility at Olkiluoto. The approach is being developed in the framework of Integrated Safeguards which, in the future, will constitute an optimum combination of all safeguards measures in order to achieve the maximum effectiveness and efficiency.

A third major issue with respect to the management and disposal of high-level waste is the multinational approach to developing a geological disposal facility. Many countries, and in particular those planning to launch nuclear power programmes, have, or will have, comparatively small volumes of high-level radioactive waste. It would appear to be disproportionately costly for each country to develop its own geological disposal facility. In line with IAEA initiatives promoting the development of shared nuclear fuel cycle facilities for its Member States, studies have been initiated at a regional level to examine the feasibility of regional disposal facilities in which the waste from several countries could be placed. For some time now, initiatives have been underway and interest expressed in multinational approaches to dealing with different aspects of the nuclear fuel cycle from reprocessing to storage of spent fuel and, more recently, disposal. The rationale is broad, ranging from the capacity of countries to develop geological disposal facilities to the availability of adequate geological formations and, fundamentally, the economy of scale. The IAEA has, at the request of its Member States, created forums for the discussion of multinational disposal, considering both the infrastructural framework and the scenarios for implementation of waste disposal facilities. In addition to cost and safety considerations, recent events have highlighted the security and non-proliferation benefits that could be gained by multinational approaches to storage and disposal.

In 2004, an international Expert Group on Multilateral Nuclear Approaches was established by the IAEA Director General to advise on possible multilateral approaches to the nuclear fuel cycle. Incentives and disincentives for multilateral cooperation at the policy, legal, security, economic and technological levels were discussed, as well as the possible roles of international organisations. The findings of this expert group were published in 2005. Increasingly, the issue of shared disposal facilities is the subject of panels at international conferences – considering possible scenarios,

conditions for successful implementation, benefits and challenges. In this context, further consultation is scheduled by the IAEA with interested countries in order to develop a deeper understanding of the legal and institutional aspects involved.

Public acceptance still remains as one of the main challenges for organisations charged with the development of any radioactive waste disposal facility. This is vital for national facilities and even more so for multinational facilities. Gaining public acceptance is not an easy undertaking and it can very easily be lost. The only real way forward in gaining acceptance is to have a very open and transparent decision-making process and to involve all relevant stakeholders and interested parties in this process, particularly local communities. How this is done will vary between countries based on their legal system and the extent that the national culture calls for participative decision-making processes. The Agency will shortly publish a document on factors affecting public and political acceptance for geological disposal, drawing on the experiences from several countries and emphasising the importance of a clear and open decision process taking into account the technical as well as the social dimension.

In conclusion, the development of geological disposal facilities is essential to the further development of nuclear power on a global scale. Fundamental to such development is communication with, and acceptance by, the public and all relevant stakeholders. Much has been achieved in developing a global safety regime and, increasingly, networks are being established that facilitate knowledge management and exchange of experience – to promote the good practice highly necessary to ensure the safety of nuclear facilities and activities. The IAEA continues to play a key role in supporting the Joint Convention, by encouraging countries to become Contracting Parties and working towards improvements in the review process, including wider sharing of the review results. The IAEA continues to assist with continuous review and improvement of international safety standards, in exchanging technical experience and in providing peer review and advisory services based on these standards. Increasingly, the Joint Convention and the amended CPPNM underpin the global safety and security regime for spent fuel and radioactive waste management. The development of geological disposal facilities for high-level waste is nevertheless contingent on building the confidence of all parties concerned in their safety. For this reason, a transparent and internationally harmonised approach increasingly becomes a *sine qua non* and perhaps the time is opportune to organise a high-level global forum for more continuous in-depth, international dialogue between implementers, regulators, policy makers and international organisations, to pave the way forward in such an endeavour.

## **European Research in the Field of Geological Disposal**

**Zoran Stančić**

Deputy Director-General, European Commission, Directorate-General for Research

Chairman, Ladies and Gentlemen,

I would like to express my thanks to the organisers for the invitation and for allowing me, on behalf of the Directorate-General for Research of the European Commission, to present this overview of the European Union's research effort in the field of geological disposal. It is indeed a privilege to have the opportunity to address such a distinguished gathering of politicians, regulators and experts on what is a key subject combining both a high political profile with significant technological and societal challenges.

As a representative of the European Commission's Research Directorate-General, I will focus my intervention today on the scientific and technical rationale. My colleague from the Directorate-General for Energy & Transport has a view more from the political and strategic perspective, particularly in relation to the continued use of nuclear energy. Clearly these different perspectives are strongly interlinked and together form a coherent Community policy on the subject of geological disposal.

The legal basis for all research in the field of applied nuclear science and technology is the Euratom Treaty, one of the founding Treaties of European integration and celebrating its 50<sup>th</sup> anniversary this year. Already 50 years ago, this Treaty foresaw the importance of carrying out research at the Community level on key issues of interest to Member States. Over the intervening years, the Euratom Framework Programmes have demonstrated that this collaboration can be extremely effective, improving our understanding of the science involved, developing a common European view on the technical issues, maximising the Community added value, and thereby ensuring protection of the public and the environment in a field with important cross-border implications.

Over the years, the focus of the Euratom Framework Programmes in the field of radioactive waste management has shifted from fundamental research on basic phenomena in the early days during the 1980s to more applied R&D in the later programmes. Throughout this period, important Community support has been provided to the research efforts in Member States in all areas of radioactive waste management, in particular geological disposal.

Late last year, the European Commission launched the 7<sup>th</sup> Euratom Framework Programme. This was unanimously adopted by all European Union Member States. Management of radioactive waste remains a key thematic priority. This includes both "partitioning and transmutation", as well as continued research on the ultimate disposal of high-level and long-lived waste in geological rock formations. The programme clearly stresses the importance of "implementation-oriented" R&D, which includes research in underground laboratories in the host rock environment, the demonstration of the actual engineering systems to be employed in disposal operations and a harmonised approach to assessing performance and safety assessment of the disposal system for eventual licence applications to the regulatory authorities. As with previous Euratom programmes, there is a considerable "leverage" effect via the shared-cost nature of the support.

During the sixth Euratom Framework Programme, from 2002 – 2006, some 90 million Euros was committed to research on radioactive waste, of which half went on projects in the field of geological

disposal. Many of the projects are still in progress. In particular, a small number of large “integrated projects” were launched covering the four principal fields of research:

- Firstly, there is the study of the so-called “near-field” – in other words the waste itself, the canister in which it is placed and the interaction with the repository environment.
- Secondly, the “far-field” – which includes the behaviour of radionuclides in the host rock and geosphere.
- Thirdly, the development and demonstration of the repository design and engineering systems.
- Fourthly, the area of performance and safety assessment methodologies requiring a more holistic approach that feeds off the results of research on individual processes.

The first of these projects will end this year. The others will finish over the next year or two. All of them are redefining the state of the art in their respective areas and the Commission believes that this will enable the geological disposal community to push forward confidently towards eventual implementation of actual disposal systems in those countries where the socio-political climate is favourable. The integrating nature of these projects is also helping to fundamentally restructure the way research is being conducted in this field in Europe.

Looking further into the past, a total of 63 million Euros were devoted to geological disposal over the 4<sup>th</sup> and 5<sup>th</sup> Framework Programmes. A significant part of this funding went on large-scale demonstration experiments carried out in underground research laboratories, for example heating experiments mimicking the effect of high-level waste canisters on the host rock. These demonstrations had to run for many years. Preparation and decommissioning of the apparatus also took years. The construction of the underground research laboratories themselves takes even longer and can face the same delays and opposition as an actual waste disposal facility. This underlines the unavoidable long-term nature of research in geological disposal and the need for continuity in the funding support – something that has been provided by the Community programme. ... If we want to get the science right we must take the time to do it properly!

This advancement in science depends on a close interplay between theory, experiment, demonstration and reproducibility of results. Throughout this process there is an important principle of peer review, expert analysis and interpretation. In a complex multi-disciplinary field it is crucial to allow this scientific consensus time to become established. In geological disposal, this process has resulted in widespread agreement within the scientific community regarding not only the feasibility of long-term confinement of radioactive waste in deep and stable rock formations, but also the fact that it is the only safe option. Significantly, this scientific community extends beyond those directly involved in the research effort itself. Many national geological societies and other academic scientific bodies have also published favourable opinion papers.

Of all the issues raised in this scientific debate, one stands out as the most intractable. How can we be assured of safety in the very long-term? Here it is important to appreciate the limitations of science – research can never provide absolute certainty, nor demonstrate that risks are zero. However, research does allow us to understand and model the processes involved. For example, the study of analogues, both natural and man-made, allows an understanding of similar processes that have occurred in the past. The best known example is the natural nuclear reactor discovered at the Oklo uranium mine in Gabon.

Two billion years, conditions were right for the uranium deposits in this region to sustain a nuclear chain reaction. This produced several tonnes of fission products, the same as found in today’s high-level radioactive waste. Crucially, all these heavy metals and fission products have remained well fixed in the

bedrock over the intervening millions of years, providing considerable assurance of the retardation properties of the geosphere. There are many other examples of analogues. For instance, the Cigar Lake uranium deposit in Canada, the durability of the cement used in the construction of Hadrian's Wall in the United Kingdom, or the well preserved nails discovered at a Roman legionary fortress in Scotland. Many of these analogues have been studied as part of the Euratom programme, and each gives an additional piece of information on how a particular element of the disposal system will evolve over time. Analogues can also be very effective in communicating the issues to a non-technical public.

Significant quantities of high-level radioactive waste already exist in interim surface storage and it is inconceivable that these accumulations remain in this situation indefinitely. Sooner or later, society must implement a permanent long-term management solution that respects high levels of safety and adequately protects the public and the environment both now and in the future. The scientific consensus is that geological disposal is the only option capable of fulfilling these requirements and most national waste management strategies now recognise this fact. These strategies must also recognise that it is the responsibility of the present generation to implement this solution, since we have benefited from the electricity produced by today's nuclear power plants.

However, to implement this option requires both political will and public acceptance, certainly in regions surrounding potential disposal sites. In this process, science must provide a neutral frame of reference in which to present technical issues. The research conducted must be beyond reproach. It must be thorough, detailed and capable of supporting robust arguments. Throughout the Euratom programmes, these have been the guiding principles.

In today's world, the issue of governance has become increasingly important in all sectors faced with the construction of controversial facilities. In radioactive waste, these issues are especially difficult and demand a high degree of transparency, constructive dialogue, trust and respect by all parties. Within the 6<sup>th</sup> Framework Programme, Euratom has also committed 8 million Euro of funding for research projects in the social sciences on these issues of governance and public acceptance. This has enabled a better understanding of broader stakeholder concerns, facilitating dialogue and the decision-making process.

Other areas of support with the Euratom programme include more strategic projects looking at the transfer of technology between larger and smaller waste management agencies, and whether countries could share waste management facilities rather than each having to construct the full range of installations. This is particularly important for Member States with small nuclear programmes, or with unfavourable geology. The Euratom programme also provides support to basic actinide science, which is important not only for research on geological disposal, but also in "partitioning and transmutation" and the fuel cycle in general.

Even though socio-political issues are now the main reasons for delays in implementation in most countries, questions of a technical nature still remain to be answered and an integrated European research effort is the best guarantee that these can be addressed both effectively and efficiently. This effort should be clearly focused on the key identified outstanding issues and solidly based on the wealth of accumulated scientific knowledge, to which must be added the results of on-going research in the 6<sup>th</sup> Framework Programme. The best people to drive this process forward are the national waste management agencies, since they are ultimately responsible for the implementation of disposal options in the respective Member States. The technical safety organisations and major research institutes are also key players and provide additional expertise, ensuring that research and the interpretation of the results are robust and reflect the state of the art.

Last month in Brussels saw the launch of the “Sustainable Nuclear Energy Technology Platform”. This was a pivotal moment in R&D in the nuclear sector in Europe, bringing together a broad range of stakeholders in the nuclear research and industrial sectors around a common vision for future research in the field of nuclear installation safety and advanced nuclear technology. The event was a big success and, later this month, the governing structure of this Technology Platform will be established and the stakeholders can begin defining the all-important “Strategic Research Agenda” and “Deployment Strategy”. This Technology Platform is particularly important in the context of the current debate on security of energy supply and climate change.

The scope of the Technology Platform also includes the nuclear fuel cycle, but with the notable exception of geological disposal. The reason for this exclusion is quite clear. The national radioactive waste management agencies, in order to maintain a high level of trust and credibility in their dealings with other stakeholders and especially the general public in the vicinity of potential disposal sites, must remain independent of any initiatives linked to the development of nuclear technology. Nonetheless, we recognise the importance of also establishing a similar “Technology Platform” approach to the European research effort in the specific field of geological disposal. Not only will this enhance integration of all research players around a shared vision of geological disposal, it will also enable a much more effective and targeted use of Euratom funding. A study being funded under the 6<sup>th</sup> Framework Programme will report back later this year on this issue. We hope this will enable the second Technology Platform to be launched next year.

With such a structure in place, and in view of the progress being made in general across the sector, the Euratom Programme will continue to provide invaluable support to national programmes in their endeavours to implement safe, timely and cost-effective geological facilities for the disposal of high-level radioactive waste.

Finally, I would just like to mention that, on 20 to 23 October 2008, the European Commission will be hosting the next Euradwaste conference in Luxembourg. This will be an opportunity to present the full range of results from the on-going Community research effort in the broad area of radioactive waste management and to take stock of the latest achievements, in particular of the large integrated projects of the 6<sup>th</sup> Framework Programme. As in the past, the first day of the conference will be devoted to Community policy and strategy in the area of radioactive waste management. I would like to extend an invitation to all present today to attend this event.

Thank you.



## **Ensuring Political and Institutional Legitimacy: Strategy and Policy in the Swedish Nuclear Waste Management Programme**

**Torsten Carlsson**

Chairman, Swedish National Council for Nuclear Waste, Sweden

### **The Swedish National Council for Nuclear Waste**

The Swedish National Council for Nuclear Waste is an independent scientific committee with the task of investigating issues regarding nuclear waste and decommissioning and dismantling of nuclear facilities, and with the task of providing the Government and certain authorities with advice on these issues. Its main tasks are:

- Reporting on the state of knowledge in the nuclear waste area (every third year).
- Reviewing of the Swedish Nuclear Fuel and Waste Management Company's (SKB) RD&D programme (every third year).
- Holding hearings and seminars within the framework of a Transparency Programme, launched during 2006, as a result of dialogue with other stakeholders in the nuclear waste management (NWM) area.

The complexity of the nuclear waste issue and the long-time perspective mean that crucial decisions must take into account scientific, societal and humanities aspects. Through its broad scientific competence in these areas, the Nuclear Waste Council gives advice on nuclear waste issues. The Nuclear Waste Council's advice has to be so well-founded that it can be the basis for the Government's standpoint. The Nuclear Waste Council identifies and analyses issues within the nuclear waste area which have considerable importance for the decision-making process and evaluation of the long-term security of final disposal and ensures that these issues are penetrated.

### **The Swedish nuclear waste management programme and time schedule**

The NWM programme is implemented by SKB and comprises a final disposal system for spent nuclear fuel and an encapsulation plant.

Since 2002, SKB has been carrying out site investigations in the municipalities of Östhammar and Oskarshamn. The results of these investigations form the basis for SKB's choice of location for the final disposal facility for spent nuclear fuel. SKB would primarily like to locate the encapsulation plant in connection with CLAB in the municipality of Oskarshamn, but the alternative of placing it in the Forsmark area in the municipality of Östhammar is also being investigated.

In 2006, SKB submitted an application to the Swedish Nuclear Power Inspectorate (SKI) according to the Nuclear Activities Act regarding an encapsulation plant. In 2009, SKB plans to submit an application according to the Nuclear Activities Act for a final repository for spent nuclear fuel and applications under the Environmental Code for both an encapsulation plant and a final repository.

There are a number of stakeholders involved in the NWM process. The Government grants licences, decides on the industry's RD&D programme and sets the fee to be paid by the nuclear industry to the Nuclear Waste Fund. The two main authorities are the Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Authority (SSI). They issue regulations and guidelines regarding safety (SKI) and radiation protection (SSI). The Swedish National Council for

Nuclear Waste is a governmental body but has, in contrast to SKI and SSI, no formal role in the licensing process (the main tasks are presented above). There is a Government decision stating the SKI and SSI will be merged into one authority which will start operation on 1 July 2008.

Other important stakeholders are the nuclear industry (i.e. the nuclear power plant owners and SKB), the two municipalities Oskarshamn and Östhammar, the County Administrative Boards and NGOs. According to the Swedish legal framework, the nuclear industry has full responsibility for safely managing radioactive waste and spent nuclear fuel and full responsibility for all costs of disposal by paying a fee (set by the Government) to an independent fund managed by a governmental board. The municipalities are central stakeholders in the Environmental Impact Assessment (EIA) consultation process that is co-ordinated by the County Administrative Boards of Kalmar and Uppsala, and have a high degree of independence (ultimately expressed in the municipal veto). The NGOs interested in the nuclear waste issue can receive funding from the Nuclear Waste Fund to participate in the consultation process. The municipalities, the County Administrative Boards and the authorities can also receive funding from the Nuclear Waste Fund.

### **Policies and requirements in Sweden**

The Swedish process is characterised by:

- Clear legal requirements:
  - Clear distribution of responsibilities.
  - Work done by nuclear industry.
  - Nuclear waste fund – paid by nuclear industry.
  - Review and licensing by Government and authorities.
  - Open review of RD&D programme every 3<sup>rd</sup> year.
- Voluntary process – municipal veto.
- Stepwise process.
- National solution, in our generation.
- EIA framework for stakeholder involvement.
- Openness, transparency and dialogue.

### **The Nuclear Waste Council's Transparency Programme**

Important aspects of the Swedish policy are requirements on stakeholder participation, transparency and dialogue. This also has implications for the Nuclear Waste Council's activities.

An important part of providing active and effective support to the Government prior to dealing with SKB's applications is to identify the key issues from different perspectives prior to the decision on the final repository and to make arguments and bases for decisions transparent by clarifying the points at issue and values to decision makers and the general public. It is also of great importance to create a dialogue around these issues between important stakeholders. The dialogue is important both from the perspective of knowledge (to identify important issues and have them highlighted and discussed from different perspectives) and from a democratic perspective (affected stakeholders must be given the opportunity to make their voices heard and issues must be highlighted in a way which is accessible to different categories of stakeholders). Therefore, the Nuclear Waste Council sees a need to broaden and develop its activities regarding the identification of important issues, to have them studied in detail and to contribute to the dialogue surrounding them.

As a result, the Transparency Programme was launched in the autumn of 2006. The purpose of the Programme is to contribute to an increase in knowledge for the Nuclear Waste Council and to strengthen the Council's role as advisor to the Government through having strategic issues investigated in detail. This should also be a resource for other interested stakeholders in the upcoming licensing process.

The Programme will be based on four components:

- i. Identification of important issues.
- ii. Specification of the format for the specific transparency activity (such as seminars and/or hearings).
- iii. Perform the transparency activity.
- iv. Documentation and analysis of each hearing or other activity.

An important part of the Transparency Programme is to have continuous dialogue with all relevant stakeholders to obtain feedback on both the issues to be brought up in the transparency arena and on the format for dialogue. It is, however, the Nuclear Waste Council that makes the final decision on what will be included in the Programme.

The preliminary programme for the period 2007-2010 is as follows:

1. Decommissioning of nuclear installations (December 2007).
2. Analysis of the system for final disposal (Spring 2008).
3. Site selection – on what grounds? (June 2008).
4. Participation and democracy (Autumn 2008).
5. Actions and authenticity in NWM (Spring 2009).
6. Site selection – an evaluation (Autumn 2009).
7. Authorities' regulations and guidance (Spring 2010).
8. Values, judgments and critical assumptions in the safety case (Autumn 2010).

### **Concluding remarks**

The above-mentioned Swedish requirements have, up till now, been successful in pushing the programme forward. However, there are still important and controversial decisions to be made in the near future and the Nuclear Waste Council will contribute to further improving the basis for these upcoming decisions.

So far, the Nuclear Waste Council has only received very positive remarks regarding the Transparency Programme from all relevant stakeholders in the Swedish programme. Also in the international arena, there is a clear interest in the Programme. Issues of transparency and participation by the general public have been given much attention during the last decade through research activities (RISCOM, COWAM, CARL, ARGONA, CIP and OBRA) and special activities by international bodies, in particular the OECD/NEA through FSC (Forum on Stakeholder Confidence). It needs, however, to be noted that a transparency programme such as the one described here requires a neutral arena where dialogue can be held. Such neutral arenas are more easily obtained by an organisation that has no formal role in the licensing process.

## **Policy and Strategy for Radioactive Waste Disposal in Japan**

**Kenji Ogiwara**

Vice-Minister, Ministry of Economy, Trade and Industry (METI), Japan

### **Introduction**

Good afternoon, ladies and gentlemen. My name is Kenji Ogiwara and I am a Vice-Minister of Economy, Trade and Industry of Japan. It is a great honour for me to have this opportunity to introduce the policy and strategy for high-level radioactive waste disposal in Japan.

### **Japan's energy policy**

First of all, I would like to introduce the nuclear energy policy of Japan.

As Japan has limited natural resources, we believe it is essential to promote the use of nuclear energy in order to both ensure a stable energy supply and help resolve the issue of climate change. In Japan, we are aiming to increase the proportion of nuclear energy production to 30-40% or more after 2030, providing that safety can be guaranteed.

As most of you will be aware, there was a strong earthquake in Niigata in July this year. The Kashiwazaki-Kariwa nuclear power plant was located close to the epicentre and experienced strong seismic effects. The nuclear reactors shut down safely, as designed, and there was no radiological impact on the surrounding environment. A detailed investigation of the effects of the earthquake on the nuclear plant is currently ongoing and the earthquake resistance of all the nuclear plants is now being reviewed. With a view to improving safety measures, and given that Japan frequently experiences earthquakes, it is our responsibility to share our experience on earthquake effects internationally. We will continue our efforts towards improving the safety of nuclear facilities both in Japan and worldwide.

### **Activities to date**

Disposing of high-level radioactive waste, which is today's topic, is an inevitable aspect of the use of nuclear energy. It is a common issue for all countries with a nuclear energy programme and each country is working hard to find a solution which is appropriate for its own situation. This is reflected accurately in the title of this meeting – "A Common Objective, a Variety of Paths". I believe that the issue of high-level radioactive waste disposal has to be seriously addressed by the current generation benefitting from nuclear energy. I would like to present three particular features of our activities in this area.

First of all, I would like to explain the framework of the final disposal project in Japan. In May 2000, the Specified Radioactive Waste Final Disposal Act was established. The purpose of this legislation is to provide for implementation of the final disposal project in a well planned and structured manner. The Act states that the disposal site will be selected through three investigation stages. The fundamental assumption is that the safety of the final disposal facility relies on the geological conditions at the selected site. Investigations therefore start with a literature survey, followed by preliminary surface-based investigations, for example with boreholes, and finally detailed investigations in an underground research facility.

Before the investigations proceed from one stage to the next, the government has to listen to and respect the opinions of the mayor of the municipality and governor of the prefecture, who in turn reflect the opinions of the local residents. The investigation area then has to be approved by the Cabinet Council. The Nuclear Waste Management Organisation of Japan (NUMO), which plays a key role in the implementation of the final disposal project, is looking for municipalities where literature surveys can be conducted using a volunteer approach. This is a notable feature of the Japanese programme – a democratic approach based on local understanding and acceptance and free from governmental pressure.

The second feature is that the Japanese government will provide between one and two billion yen in subsidies to the municipality during the investigation phase, before the stage where the site is potentially selected for construction of a repository. This is based on the fact that the final disposal project will extend over a long time period, and it is important that the municipality should be in a position to develop together with the project.

The third feature is that the Japan Atomic Energy Agency (JAEA), which is a public sector research institution, is constructing deep underground research laboratories at Mizunami in central Japan and Horonobe in northern Japan. In these laboratories, tunnels are excavated and research is carried out on investigation methods for understanding deep geological environments and developing safety assessment methodologies. The sites for these underground research laboratories will not come into consideration as repository sites. As a result of opposition during the selection of the sites, JAEA and the local governments have an agreement that the sites will not be used for radioactive waste disposal.

### **Interest from municipalities**

As announced in the press, more than 10 municipalities have expressed an interest in being considered as volunteer sites within the site selection framework I mentioned previously, following NUMO's public relations activities and support by the government.

Under these circumstances, Toyo town in Kochi prefecture was the first municipality to submit an application for a literature survey in January 2007. However, after submission of the application there was an escalation in opposition activities, including groups from areas outside the town. This led to a decision to request the resignation of the mayor and to hold a new election. The mayor therefore decided to resign and an election was called to allow the local residents to make a decision. However, the candidate opposing the literature survey was elected and the literature survey was abandoned. No other municipalities have applied for a literature survey since these events.

### **Lessons learnt from past experience and future activities**

Reflecting on past experience, some issues have become clear. Opinions have been expressed by Diet members and various stakeholders as to whether greater efforts to bring forward the disposal programme might be necessary. Against this background, the advisory body to the Minister of Economy, Trade and Industry has now proposed additional measures for promoting the site selection process. I would like to introduce some aspects of these measures.

The first point is to enhance nationwide PR activities, including briefings at the prefectural level. The final disposal project is not only an issue for local residents in an investigation area, but also for all citizens who benefit from nuclear energy. It is therefore important to increase awareness of the project and, with this, hopefully cooperation. It is also important to provide people with the opportunity to learn about the results of scientific research, for example by providing facilities where they can physically experience aspects of the disposal project. One possibility is to create a virtual repository using computer technology. I have studied numerous documents on the concept of final

disposal and the associated safety measures, but I am planning to visit one of the Swiss underground research laboratories as I strongly believe that “A picture is worth a thousand words.”

The second point is promoting PR activities in areas which show an interest in the final disposal project. It is important for the government to improve PR activities in such areas, in order to provide clear and accurate information on the safety of final disposal, the site selection procedure and regional development plans.

The third point is to establish a system whereby the government can nominate municipalities with the offer of a literature survey, in addition to the volunteer approach by NUMO, to demonstrate the government’s greater commitment to the site selection process. If the mayor of a municipality decides to apply for a literature survey, this presents a considerable burden in terms of convincing the local residents. We expect that the offer system with respect for local opinions will, to some extent, alleviate this situation.

The fourth point is to present a regional development plan. The final disposal project timeline, with its phases of investigation, construction, operation and closure, will continue for more than 100 years. We believe it is important to develop the affected region and to ensure that a good relationship is maintained with the project as it progresses over the years.

The fifth point is international collaboration. Radioactive waste disposal projects are a common concern to all countries with a nuclear energy programme. We are convinced of the importance of exchanging information and experience, including various areas of research, on an international basis. With this in mind, Japan is hoping to host the next meeting in this series in 4 years’ time. Aside from the international aspect, we also hope that this would have the effect of moving the final disposal project in Japan forward and increasing awareness on the part of the public.

The aim of the Japanese government is to start operation of the repository around the middle of 2030. Based on the measures foreseen for the promotion of siting, it is expected that the government, NUMO and the utilities will dedicate themselves to performing their respective duties in implementing the disposal project.

Thank you very much for your attention.

## **Fundamental Issues Concerning Nuclear Waste Management and Disposal**

**Georg Arens**

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany

It is my great pleasure to bring special greetings from Environment Minister Gabriel to Federal Minister Leuenberger, Mr. Luis Echavarrri and Mr. Walter Steinmann.

Mr. Gabriel and his Parliamentary State Secretary, Mr. Müller, greatly regret being unable to attend this event due to other pressing commitments. This is particularly true for Environment Minister Gabriel who, as former Minister President of the Federal State of Lower Saxony, has strong ties with the issue of waste management. As Member of Parliament for a constituency in Lower Saxony in which one repository is being decommissioned and one constructed, he is also personally affected by the issue.

Germany is currently going through all the phases of a waste disposal project. The Morsleben repository for low- and intermediate-level waste in Saxony-Anhalt and the Asse Mine in Lower Saxony, in which low- and intermediate-level waste was also disposed of, require to be decommissioned. For the two facilities, this is ultimately expected to cost more than two billion Euros. These, then, are good examples of how not to proceed if future generations are to be spared large financial burdens or doubts about the safety of a repository. Repository safety begins with the site selection process and emplacement of waste in a facility should be undertaken only when the feasibility of the decommissioning concept and the long-term safety of the repository have been demonstrated beforehand clearly and without doubt.

The construction of the Konrad repository, planned for a capacity of 303 000 m<sup>3</sup> of radioactive waste with negligible heat production, began in May 2007, following official approval of the plans by the Federal Administrative Court in spring of the same year. According to the current timetable, the repository will start operating at the end of 2013.

It still remains open in Germany how a site will be selected for a repository for high-level/ heat-producing waste. In the opinion of Minister Gabriel, the decision in 1977 that the Gorleben salt dome would host a repository for all types of radioactive waste should be reviewed as part of a selection procedure carried out in accordance with the current status of science and technology. Only in this way can a siting decision be said to meet requirements in terms of best possible safety and transparency. The Federal Government has not yet reached a decision on this issue.

Against this background, the Minister sees the developments in Switzerland as being very positive and he welcomes the decision to adopt the sectoral plan procedure for selecting repository sites. He made this clear in his official response of 27 April 2007 as part of the open consultation process for the draft of the strategic part of the plan. Together with the Federal State of Baden-Württemberg and districts and communities on the German side of the border, the Federal Ministry for the Environment will continue to be involved in the search for sites in Switzerland. It is exemplary that the sectoral plan concept foresees involvement not only of the Swiss public but also of neighbouring countries, in the case where a repository will be sited close to a national border. The interest of the German people in the Swiss process is clear from numerous letters and resolutions, and also in particular from the active participation in development of the sectoral plan concept at a public event held in Lottstetten, a German town near the Swiss border. On this occasion, a large number of people from the area came together to discuss the concept proposed by the Swiss Federal Office of Energy.

There are still those who doubt the view that cross-party participation of an affected region is possible despite differing focuses of interest. This can be countered with the experience of the Federal Ministry for the Environment in setting up a cross-party supervisory commission on the German side and the establishment of an expert support group. People are open to arguments if they are transparent and the procedures involved are perceived to be fair. Minister Gabriel is therefore in favour of a transparent procedure structured according to clear criteria for selecting a disposal site for particularly hazardous high-level waste. Following the example set by Switzerland, there should also be broad involvement of the public in the German site selection procedure.

At the end of 2006, the Federal Ministry for the Environment put forward a proposal regarding alternatives to Gorleben for discussion by the Federal Government. This was based on the proposals already developed in 2002 by the AkEnd group, which was responsible for specifying scientifically based criteria for site selection. In contrast with AkEnd and the Swiss sectoral plan procedure, both of which start from a blank map with no prior specification of siting possibilities, the proposal by the Ministry focuses particularly on the Gorleben site, because extensive investigations have already been carried out there and 1.4 billion Euros already invested in the project. According to the proposal, another site should only be selected and investigated when it promises clear advantages over Gorleben in terms of safety. Advantages or disadvantages with respect to safety can only be assessed in a credible way if the selection criteria and safety requirements have been specified in advance with the involvement of the public. A first draft of such safety requirements is presently being prepared by the BMU and discussions in technical circles have already begun. However, it has become clear that, for many people, it is difficult to move away from habitual perspectives. It would therefore be beneficial if the international scientific status regarding radioactive waste disposal and the procedures for defining safety criteria were more reproducible and transparent for the public. Understanding disposal concepts and safety standards in other countries has a considerable impact on acceptance of national disposal projects. In this respect, the Ministry of the Environment hopes for positive signals from this conference.

It must, however, be said that the future role of nuclear energy in electricity production significantly influences the disposal debate. A clear position on limiting the use of nuclear energy makes it easier for many people to accept projects for radioactive waste disposal.

As already mentioned, Germany has very diverse experience with the question of waste disposal. This experience should be used to provide input to the discussions during this conference. The ultimate aim is to determine how the fully justified call by the public for the best possible safety of waste disposal and for fairness in siting decisions can be fulfilled. The situation where real doubts about the safety of a site and the objectivity of its selection remain after decades of work and investments in the billions must be avoided. In this respect, there is much to be learned from the deliberations in Germany over the Gorleben site, as well as from the increasingly controversial discussions surrounding the Yucca Mountain site in the USA.

Minister Gabriel wishes all participants a successful conference, with numerous opportunities for interesting and open discussions.



## Societal Aspects and Ethical Issues

**Professor Carl Reinhold Bråkenhielm**  
Swedish National Council for Nuclear Waste (KASAM)

Let me begin with a quote from a hopeful Swedish philosopher: “Ethics should not only be a spice on an already prepared meal, but a part of the very recipe of the dish!” It seems that he is up to a rather tall order. The world of ethical principles and abstract reasoning is mostly far – very far – removed from practical reality, where concrete decisions have to be made. But there are promising points of contact. One is the discussion on sustainable development. On the publication of the World Commission’s Report on Environment and Development, *Our Common Future*, in 1987, Gro Harlem Brundtland made an inspiring speech. She spoke about the development of a “new holistic ethic in which economic growth and environmental protection go hand in hand around the world.” At the core of this holistic ethic was the idea of sustainable development. The classical definition was as follows:

“Development that meets the needs of the present generation without compromising the ability of future generations to meet their needs (p. 43).”

In the discussion about sustainability, it has become customary to make a distinction between weaker and stronger views on sustainability. How far can the agenda of sustainable development be reduced to the workings of neoclassical economy? Simply said: how much can we rely on market mechanisms to provide us with a sustainable society? Proponents of *weak sustainability* suggest that we can rely more or less completely on the workings of the market economy. Bryan Norton refers to the welfare economist Robert Solow – winner of the Nobel Prize in economics in 1987. He argues that, as long as the future is richer, they will have no right to complain, because they will be able to buy what they need and desire (Solow, 1991). Bryan Norton calls this line of argument the Great Simplification: the best we can do for the future is to accumulate as much wealth as we can by economic, social and technological development. In fact, we have only two simple obligations to the next generation; they in turn to the next and so on (Norton, 1995). In sum, we owe future generations wealth and flexibility – that’s all.

In short, *weak sustainability* is based on the presumption that losses of environmental resources (natural capital) can be made up by innovation, ingenuity, imagination and adaptation. *Strong sustainability* favours political regulations. Our duties towards future generations are not automatically executed by building as much wealth as possible for the next generations. In *best available technique criterion* philosophical terms, wealth is a necessary, but not a sufficient, condition for sustainable development. Strong sustainability calls for political restraints on the unfettered market.

If we go for strong sustainability, what should be our guiding ethical principle? One possibility is the no-harm or minimal principle of justice. This is the main principle in the Regulatory Framework of the Swedish Radiation Protection Agency (SSI, 1998) and can be summarised in the following way: nuclear waste should be disposed of in such a way that there is only one chance in a million that such a kind of exposure leading to human injury or death occurs.

Needless to say, it is a project of mind-boggling proportions to make credible that a certain repository for nuclear waste meets the no-harm criterion – and meets it for at least 100 000 years. Therefore certain other more manageable criteria, such as (1) the best available technique (BAT) have to be added. To obtain a green light for construction of a repository, SKB (the Swedish Nuclear Fuel and Waste Management Co.) has to show that they have used the best available technique when it

comes to localisation, design, construction and functioning of the repository. Furthermore, they have to meet (2) *the optimisation criterion*, i.e. using the best available methods of risk analysis to minimise the risks. All these criteria – no-harm, BAT, optimising – must be applied in awareness of uncertainty.

Let me proceed further on the assumption of strong sustainability. Unfortunately, advocates of strong sustainability face a number of problems. The first is the *ignorance problem*. We do not know what future people want and need. When it comes to the construction of a repository for nuclear waste, the problem may not be that difficult. We may simply construct in such a way that allows future generations to access the waste and make whatever use of it they might wish. But there are at least two problems with this. First, it may hamper the long-term protective capability of the repository. But, secondly and more seriously, the repository is not only constructed to protect those outside from what is inside, but also to protect what is inside from outside intrusions by those who wish to use the material for destructive purposes, for example for the purpose of producing nuclear weapons. Possibly, the best strategy would be to ignore the ignorance problem and construct a repository with maximum protective capability without any considerations about the freedom of action of future generations.

Secondly, there is the distance problem. Is it really meaningful to speak of a moral responsibility to remote generations? It is beyond our capacity to influence a distant future. Anver de-Shalit writes:

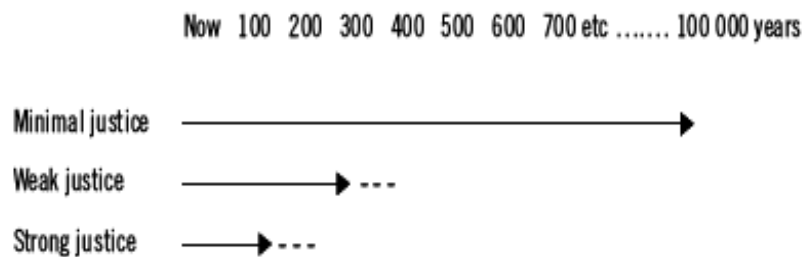
A theory of morality ... should not demand the absolutely impossible. If people are told that they should share natural resources, e.g. coal, with people who would be alive six or twelve generations from now, they will at least listen and may even tend to agree. But if they are told that they should share access to coal with someone living in the year 2993 or 3993, the response will probably be “To hell with morality and intergenerational justice! This is ridiculous; such policies do not make any sense because they are inconceivable!” (de-Shalit, 1995, p. 14).

This is an understandable reaction, but is it really morally justified? The famous philosopher Peter Singer once argued that *spatial* distance is not morally relevant. The fact that certain people live on the other side of the globe does not relieve us of moral responsibility. “... [I]f it is in our power to prevent something bad from happening, without thereby sacrificing anything of comparable moral importance, we ought, morally, to do it” (Singer, 1972, p. 230). Similarly, one could argue that we do indeed have obligations even to persons in the remote future and that there are no time-limits to these obligations. That the bad thing is far off in the future, say 50 000 years, is not morally relevant. Saying that people in the very remote future do not have the same rights as we do now is discrimination of the same morally appalling character as saying that women or coloured people do not have the same rights as white men.

Thirdly, there is *the extent problem*. How extensive are our obligations to future generations? Are our obligations independent of time? Or do they diminish with time? Is there even a point in time when they vanish?

In KASAM’s state of the art report of 2005, Mikael Stenmark and I propose the idea of diminishing responsibility (IDR). It is constructed out of three different principles which define our obligation to future generations: the minimal, the medium and the maximal principle of justice (terminology somewhat different from the state of the art report). The *minimal principle* underlines future generations’ right to protection from avoidable injury and death. The *medium principle* speaks about their basic needs and the *maximal principle* about their rights to an equivalent quality of life to ours. Each of these principles covers different time lines, as is illustrated by the following figure.

Figure 1. Three timelines that define the main applications of the principles of justice in time.  
(From *Nuclear Waste. State-of-the-Art Report 2005*. KASAM, p. 440)



Let me comment on each of these principles of justice and their time lines:

- The *minimal* principle ungirds the requirement for a repository with preventive capability as long as the nuclear waste provides a threat to humans and the environment. There might even be geological possibilities in Sweden for constructing such a repository – the burden of proof is on SKB, The Swedish Nuclear Fuel and Waste Management Company.
- The *medium* principle states that we do not only have a negative duty to protect future persons from harm; we also have a positive obligation to satisfy their basic needs. But at some point in the future our capability of exercising such a positive influence diminishes to zero. At some point, we become totally incapable of determining which of our actions truly have positive effects on future generations. Will a geological repository help people in the future to satisfy their needs? Let us focus on their need for flexibility. They may need to retrieve the waste for something they find valuable or to destroy it in a way we were unable to do. I cannot imagine how our construction of the repository could influence people in – say – 10 000 years. But by some stretch of the imagination I might conceive how a repository could facilitate or hinder retrieval for persons living in say 2300. Beyond some such point, the positive effects of our actions today simply fade away. The weak principle of justice asks us to respect future generations’ right to flexibility and facilitate their retrieval of the waste.
- The *maximal* principle of justice is even more demanding: we are obliged to give future generations the possibility to achieve an equivalent quality of life, possibly even better. To be sure, we can influence the world which our children and grandchildren will inherit. And to some extent the situation of our grandchildren. But, after 5 or 6 generations, we cannot tell what our actions really amount to. If we live under the obligation to make the world a better place at least for our children, our grandchildren and their children, our technology should not be an undue burden to them. But what follows for our management of nuclear waste? Should our main policy be final disposal of the nuclear waste, constructed out of financial resources in some kind of nuclear waste fund? That is required by proponents of strong sustainability. And they could also refer to the precautionary principle: take care of the waste while you can – tomorrow might be too late! Advocates of weak sustainability would be less eager to find a final solution – and put less emphasis on funds and government regulations. As long as the future is richer, they will have no right to complain, because they will be able to buy what they need and desire – including a repository.
- Whatever the merits and defects of this theory of diminishing responsibility, it must be complemented with some other idea of how different generations are linked together in a common responsibility. Following an American idea, we may call it the idea of the *rolling present*. The basic concept of the “rolling present” is that the present and the future are interlinked through human beings and institutions, which carry obligations and possibilities

for development from one generation to the next. Such a chain makes it possible to identify new uncertainties on the basis of new knowledge and to formulate improvements. In sum, we should (1) preserve the gains that our culture and civilisation have made for posterity, (2) maintain our just institutions – and those institutions that maintain justice – intact, and (3) pass on to future generations a greater capital, in the form of more knowledge and better developed technology, than we ourselves received from previous generations. This should compensate future generations for what we have consumed and pave the way for a better life in a society that is more just than today's. In brief: *we should give future generations no less than we have received ourselves and preferably somewhat more at the same time so that we prepare them for as much freedom of action as possible.*

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## **Social Aspects of Developing a Management Approach: the Case of NWMO in Canada**

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### **Introduction**

The Nuclear Waste Management Organisation (NWMO) was tasked through federal legislation with conducting a study of approaches for the long-term management of Canada's used ("spent") nuclear fuel and recommending a preferred approach to the Government of Canada. This study was completed in 2005. On June 14, 2007, the Government issued its decision, selecting NWMO's recommendation of Adaptive Phased Management, the endpoint of which is long-term isolation of used fuel in a deep geological repository. With this decision, NWMO becomes the agency responsible for implementation. It was societal direction which led to the design of Adaptive Phased Management and it is societal direction which will continue to provide the foundation for implementing the management approach. The fundamental critical role of dialogue, collaboration and overall societal involvement in the design of a management approach for Canada is a direct response to how the issue has evolved over the past 30 years in Canada.

### **The unique Canadian context**

Notwithstanding decades of research on the science, technology and engineering of storage and repository concepts, the task of implementation has proven challenging. One of the approaches – deep geological disposal in the Canadian Shield – was developed by Atomic Energy of Canada Ltd. and was the subject of an extensive environmental assessment in Canada through much of the 1990s. This assessment concluded that while, on balance, the safety of the deep geological disposal concept had been adequately demonstrated from a technical perspective, the same was not true from a social perspective. In reporting on its findings, an environmental assessment panel, headed by Blair Seaborn, indicated that the concept had not demonstrated the required level of public acceptability to be adopted.

Taking into account the findings of the panel, the Government of Canada established the legislative framework for addressing the long-term management of Canada's used nuclear fuel. The *Nuclear Fuel Waste Act [2002]* requires that the nuclear energy corporations establish NWMO and that waste owners finance the approach. This federal legislation set out the focus of NWMO's early mandate, which was to conduct a study of options for the long-term management of used nuclear fuel and, within three years, to present a recommendation and implementation plan to the Government of Canada. As part of NWMO's mandate, the organisation was required to study, at a minimum, approaches based on three specific technical options: deep geological disposal in the Canadian Shield, storage at nuclear reactor sites and centralised storage either above or below ground. Consultation with the general public and Aboriginal peoples in Canada was an explicit part of NWMO's mandate. Furthermore, in conducting a comparative study of risks, costs and benefits of the management options, the *Nuclear Fuel Waste Act* required NWMO to take into account ethical, social, economic and financial, as well as technical, considerations.

This Canadian experience suggested that, in order to be accepted, any management approach for Canada must reflect the values, principles and objectives of citizens at a fundamental level.

## NWMO's response: the important role of societal engagement

NWMO sought to:

- Develop a recommended management approach *collaboratively* with Canadians.
- Propose a management approach that would be *socially acceptable*, as well as technically sound, environmentally responsible and economically feasible.

At the heart of this undertaking was an understanding that managing decisions about risk and uncertainty, and what constitutes safety, is the domain of not only specialists but also of citizens. While experts can define risk, and even propose ways to mitigate it, ultimately ***it is society that determines which risks it will accept***. Values and deeply held beliefs matter. Ethical questions arise; they are fundamental and must be considered.

NWMO's study of management approaches was designed as a dialogue, conducted through four phases over a three-year study period beginning in fall 2002. Each of these phases of engagement was centred on a key decision in the evolution of the study and iterative development of the preferred approach. Citizens and specialists were asked to provide direction on four key elements:

- The questions which ought to be asked and answered in the study and the key issues to be addressed in assessing the different management approaches.
- The range of technical methods that ought to be considered in the study.
- The risk, costs and benefits of each management approach.
- The design features of a preferred management approach and its implementation plan.

NWMO invited citizens to identify the basic human values, ethical principles and objectives that they felt should be applied when assessing the different management approaches.

### Putting dialogue and collaboration into practice

NWMO heard from citizens that the study process needed to be transparent, broadly accessible and inclusive and firmly grounded in knowledge and expertise. NWMO also took into account the learning from international collaborative efforts such as the NEA Forum on Stakeholder Confidence.

***Transparency and multiple points for public dialogue and reflection were key to the study design.*** Four phases of dialogue were promoted by public discussion documents designed to share what NWMO had heard from Canadians to date, describe how NWMO was incorporating that input into the study, solicit input to shape and direct subsequent steps in the study and test conclusions as they were developed.

***A range of dialogue techniques*** were tailored to engage interested individuals and organisations in ways which might best meet their individual needs. Thus, a variety of methods were used. For example, NWMO convened a National Citizens Dialogue on Values in cities across the country to explore, with a representative cross-section of citizens, the values which should drive decision making on this issue. NWMO established a Roundtable on Ethics involving a broad range of practitioners to help make explicit and ensure systematic integration of ethical considerations in the study process and assessment. E-dialogues and topical workshops are other examples of the range of engagement processes adopted by NWMO for the study dialogue.

***Aboriginal peoples asked to design their own dialogue processes.*** Aboriginal dialogues, designed, conducted and reported on by 15 Aboriginal organisations, with NWMO support, engaged participants through more than 150 meetings.

*Throughout the process, NWMO sought to invite a broad diversity of perspectives into the process.* Focus was on multi-party dialogues convened to provide a forum for citizens and specialists with different viewpoints to talk to one another and build an understanding of other perspectives. This approach reflected NWMO's belief that progress in developing social acceptability would only come through *genuine dialogue*. Through this process, NWMO sought to identify common ground and shared perspectives, as well as foster understanding of differing points of view.

Although the focus of dialogue activities was to engage a broad diversity of perspectives, rather than numbers of participants, more than 50 000 people expressed interest in the study by visiting the NWMO website. NWMO conservatively estimates that more than 18 000 citizens actively contributed to the study, including more than 500 specialists in scientific (natural and social sciences) and technical disciplines related to used nuclear fuel management.

### **The search for common ground**

NWMO attempted to design its study to learn from diverse perspectives, but also to explore common ground which might serve as the foundation for developing a path forward.

Early in the study, common ground emerged concerning the set of *values, ethical principles and objectives* that Canadians said are important in assessing the appropriateness of any long-term management approach for used fuel in Canada, and which should drive decision making.

Common ground later emerged with respect to how to choose among management approaches, each of which offers strengths and limitations in light of citizens' objectives. *Adaptive Phased Management*, a "fourth option", emerged from the study dialogue as citizens and specialists sought an approach that built upon the strengths of the other options.

In a third area, much agreement emerged amongst citizens and specialists alike concerning the *principles and expectations for implementation* – how decisions will be taken, how citizens will be involved and how any management approach will be implemented and monitored over time. NWMO heard that responsible management entails more than technical repository design. Implementation requires a commitment to *process* that, through inclusiveness, integrity of decision making, responsiveness to citizen concerns and commitment to continuous learning, will remain aligned with societal values and expectations.

It is this common ground that established the path forward.

### **Societal requirements for implementation**

NWMO heard that a well designed implementation plan must feature prominently in an acceptable management approach. NWMO received very specific direction from the dialogue on the requirements of an appropriate implementation plan. For instance:

- Begin the initial steps toward implementation now.
- Provide future generations with genuine choice in implementation.
- Adapt to new learning and new developments in science and technology.
- Make safety for people and the environment the primary consideration.
- Build understanding of potential risks.
- Require siting to meet social and ethical requirements, in addition to technical requirements.
- Respect Aboriginal rights, treaties and land claims.
- Monitor emerging research and technical developments in Canada and internationally.

- Ensure citizens are informed, with a voice at each stage of the process; involve the public at each step.
- Communicate clearly the decision-making process and responsibilities.
- Prepare future generations for their responsibilities.

### **Adaptive phased management: responding to societal requirements**

As a result of this direction, Adaptive Phased Management prominently features design elements such as the following:

- Phased decision-making process.
- Sustained engagement and collaborative decision making.
- Strong and ongoing research programme, including international cooperation, to facilitate continuous learning.
- Extended monitoring and provision for retrievability.
- Open, inclusive and fair site selection process, which seeks an informed, willing host community.

### **Commitments and challenges**

Having received the implementation mandate from the Government in June 2007, NWMO is now preparing to take the first steps as the agency responsible for implementation. The way forward will be guided by the societal values, principles and process commitments now embedded in Adaptive Phased Management, which form part of the terms and conditions of our social license to proceed.

Adaptive Phased Management carries some pre-eminent commitments to Canadians:

- It commits NWMO to embrace adaptability, guided by ongoing dialogue and new learning.  
For example, adaptability demands a willingness to allow new knowledge to influence the path in ways that may not be wholly predictable today. Canadians expect the implementation of Adaptive Phased Management to be responsive to advances in technology, natural and social science research, Aboriginal traditional knowledge and societal values and expectations.
- It commits NWMO to an inclusive, collaborative process of decision making.  
A commitment to continued inclusion and collaboration throughout implementation demands new and appropriate processes to support each key decision point. For instance, NWMO has committed to the collaborative development of the process that will be used to identify possible willing host sites. Similarly, the technical and social research agendas will be established collaboratively. Mechanisms will need to be found to facilitate this type of dialogue and involve citizens and specialists in such key areas. Important questions arise concerning key concepts, such as “capacity building” to support sustained involvement – and what this means in light of a commitment to dialogue processes which are designed to be sustained over decades.

In light of commitments to adaptability, inclusion and collaboration, implementation can only be expected to proceed as expeditiously as social circumstances and technology demonstration allow. Fixed timeframes and schedules have to be set aside in favour of providing flexibility in pace and manner of implementation.

- It commits NWMO to be an open, transparent and accountable learning organisation.  
A commitment to openness, transparency and accountability demands an examination of business processes to find ways to ensure that the knowledge, insight and understanding built



through research, development and implementation activities by NWMO, experts and citizens are accessible to all those who are interested – society as a whole and, importantly, future generations. A particular challenge of implementation involves building capacity in the process such that it transfers knowledge and sustains momentum across generations.

NWMO looks forward to working with those in the international community to both share experiences and increase our understanding of how to approach the many shared challenges.

## **Searching for a Suitable site in Switzerland – the Sectoral Plan for Deep Geological Repositories**

**Michael Aebersold**

Head of Radioactive Waste Disposal Section  
Swiss Federal Office of Energy, Switzerland

### **Introduction**

Switzerland's first nuclear power plant, Beznau I, went into operation in 1969. The National Cooperative for the Disposal of Radioactive Waste (Nagra) was established three years later, in 1972. Nagra was entrusted with the mandate of finding a safe, long-term solution for the disposal of all radioactive waste produced in Switzerland – a mandate that still has to be fulfilled. At present, radioactive waste is being stored safely in special containers in well secured halls in an interim storage facility in Würenlingen and at the nuclear power plants themselves. However, this radioactive material needs to be disposed of safely for up to a million years and, for this purpose storage at the surface is not a suitable strategy.

Today, fully developed concepts exist for the permanent disposal of radioactive waste in geological formations, but so far it has not been possible to find a site for a repository in Switzerland.

With the new legislation that entered into effect in February 2005 (Nuclear Energy Act and Nuclear Energy Ordinance), the Federal Government adopted a new approach: the search for suitable sites is now to be carried out within the scope of a sectoral planning procedure. Sectoral planning is a tried and tested instrument that the Swiss Federal Government uses for planning and coordinating major national infrastructure projects. The objective of the sectoral plan for deep geological repositories is to ensure that, as major projects of national importance, the repositories can be decided upon and constructed on the basis of an independent, transparent and fair procedure. This process is managed and coordinated by the Swiss Federal Office of Energy (SFOE).

### **Legal provisions governing the management of radioactive waste**

In addition to specifying the implementation of a sectoral plan, the Nuclear Energy Act and its accompanying Ordinance stipulate various other fundamental provisions governing the management of radioactive waste:

- All radioactive waste produced in Switzerland must be disposed of within Swiss sovereign territory.
- Producers of radioactive waste are responsible for ensuring its safe long-term disposal (“polluter pays” principle).
- Radioactive waste must be disposed of in such a manner as to ensure the permanent protection of human beings and the environment. Experts agree that this can be accomplished by disposing of waste in stable geological formations. The Nuclear Energy Act therefore stipulates that deep geological repositories are to be used for the disposal of all radioactive waste. Once a deep geological repository has been put into operation, it must be monitored for several decades and the waste must remain retrievable.

The new legislation no longer recognises a right of veto of a project on the part of cantonal authorities. However, it provides for an (optional) national referendum which may be initiated against the granting of a general licence for a deep geological repository.

## **Transparent and fair selection procedure**

The Swiss Government has developed sectoral plans for numerous major infrastructure projects of national importance, for example in the areas of civil aviation, transport, defence and high voltage transmission lines. Sectoral plans are developed on the basis of close cooperation between the Federal Government, cantonal governments, competent authorities, other organisations and the authorities of Switzerland's neighbouring countries. The involvement of the general public in the sectoral planning process is also called for in the Federal Spatial Planning Act.

The sectoral plan for deep geological repositories represents a new concept in a number of ways: for example, never before has a sectoral plan been conceived for infrastructure of such a lasting nature, and it is probably safe to say that never before have such widely diverging political values clashed with respect to a sectoral plan. For many, the disposal of radioactive waste is closely intertwined with the issue of continued use of nuclear energy. The demands placed on the selection procedure are thus extremely high and it is essential to ensure that clear guiding **principles** are defined for the sectoral plan:

- The permanent protection of human beings and the environment is of the highest priority; it takes precedence over spatial planning, economic and social aspects.
- The search for a suitable site is based on the quantities of waste that are produced from the operation of the existing nuclear power plants in Switzerland. After these facilities have been decommissioned and dismantled, there will be a total volume of around 110 000 cubic metres of radioactive waste (including containers) to be disposed of. The definitive quantity will be specified when an application for a general licence for a specific site is submitted. In this regard, the sectoral plan does not establish a prejudice for or against future nuclear power plants.
- A transparent and fair procedure is an essential prerequisite for achieving the principal objective of the plan, i.e. finding acceptable sites for deep geological repositories. This will only be possible if both the procedure and the decisions that are subsequently taken meet with the necessary degree of acceptance.

## **Involvement of all interest groups as a crucial factor**

Sites for facilities such as deep geological repositories, which are of major importance and of a lasting nature, cannot simply be decreed "from above". Rather, they have to be selected on the basis of public debate. In Switzerland, citizens can voice their opinions either through instruments of direct democracy (votes, referendums, etc.) or via procedural processes (hearings, objections, etc.). However, these instruments are only effective at the end of a given procedure. Findings over the past 30 years at the international level have shown that a site selection procedure can only be successful if it is perceived by all parties and interest groups as a fair and transparent process in which everyone concerned can play a part. It is therefore essential to ensure that the applicable "rules of the game" governing the selection of suitable sites are defined in a clear and transparent manner. Social concerns have to be taken seriously and it is important to secure an ongoing and open dialogue. Otherwise it will not be possible to gain the necessary degree of trust in the actors involved and confidence in the various processes. The aspect of consultation is therefore a highly important component of the sectoral plan for deep geological repositories and the possibilities for involvement extend beyond the legally prescribed minimum. While this does not guarantee success, it nonetheless creates a sound basis for increasing the chances of acceptance of proposed sites for deep geological repositories.

## Concept and implementation

The sectoral plan is divided into two parts: a conceptual part, in which the rules governing the selection procedure are defined, and an implementation part, in which the individual stages of the selection process leading to detailed plans and specific locations of suitable sites for deep geological repositories are specified.

Figure 1. **The two parts of the sectoral plan for deep geological repositories: concept and implementation**

<b>Concept</b>	<b>Implementation</b>
<p>“Rules of the game”.</p> <ul style="list-style-type: none"><li>– Selection criteria.</li><li>– Selection procedure.</li><li>– Involved players.</li></ul>	<p>Selection of site in accordance with concept.</p> <ul style="list-style-type: none"><li>– Selection in three stages.</li><li>– Integration of specific plans into Deep Geological Repository Sectoral Plan.</li><li>– Application for general licence including safety and security reports, environmental impact statement, report on compliance with area planning requirements.</li></ul>

## Two repositories

Switzerland’s geology has been the focus of intensive research for more than 200 years. The findings have been documented in numerous geological maps and scientific reports and the resulting know-how has also been deepened through geotechnical and seismic studies conducted for the purpose of exploring for raw materials. During the past twenty-five years, Nagra has been contributing towards a better understanding of Switzerland’s geology by drilling boreholes and through other activities in two underground research laboratories. The sectoral plan documents the studies carried out to date, as well as the geological findings. They form a broad basis for the search for suitable sites.

Switzerland’s nuclear waste management concept calls for two repositories: one for low- and intermediate-level waste and another for high-level waste. Alpha-toxic waste can be disposed of at either of the sites. In the event that one particular site is identified as suitable for all three waste categories, the selection procedure could result in the proposal of a single site for the repositories.

### Selection criteria: safety has the highest priority

The concept part of the sectoral plan specifies the criteria that potential sites have to meet. Here, criteria relating to safety head the list. A proposed geological formation must ensure the safe disposal of radioactive materials over the required extended time frame.

The safety criteria are initially defined in qualitative terms and include aspects such as the extent and depth of the rock formation, its long-term stability and its hydraulic barrier effect. The safety of a given site is based on the interaction between various natural local factors, but it also depends on the nature of the waste to be emplaced and on other technical aspects (e.g. disposal containers). As the procedure progresses, the requirements relating to safety become more specific in accordance with the relevant guidelines of the Swiss Federal Nuclear Safety Inspectorate (“Protection Objectives for the Disposal of Radioactive Waste” – HSK-R-21).

Only those sites that meet the specified safety requirements can be potential candidate sites. In addition, spatial planning and socio-economic aspects of these potential candidate sites are evaluated and the corresponding impacts of a deep geological repository on the region concerned are closely examined.

### **Site selection procedure: three stages**

The site selection procedure is carried out in three stages:

- Stage 1: Selection of geologically suitable regions for low-/intermediate-level waste and high-level waste

Nagra, representing the producers of radioactive waste and responsible for waste disposal, proposes geologically suitable regions on the basis of the relevant safety criteria and substantiates its selection in a report for the attention of the Swiss Federal Office of Energy.

The Federal Government then notifies the authorities of the Cantons and municipalities concerned. A cantonal committee is formed, in which the involved Cantons and neighbouring Cantons are represented. Neighbouring countries that are affected are also entitled to sit on this committee. Together with the committee, the SFOE then specifies the suitable regions and sets up regional consultation bodies in these regions.

The next step, which is initiated by the responsible federal authorities in cooperation with the Cantons concerned, is to take stock of the current situation and to define the methodology for determining the most important spatial planning aspects and their subsequent assessment in Stage 2.

Once this criterion is met and the safety assessment is completed, the geologically suitable regions are adopted. This is done in the form of preliminary proposals, following a three-month consultation period (in accordance with the Swiss Federal Spatial Planning Act) and subsequent approval by the Federal Council. The regions identified are then adopted into the sectoral plan.

- Stage 2: Selection of at least two sites each for low-/intermediate-level waste and high-level waste

In stage 2, at least two sites each for low-/intermediate-level waste and high-level waste have to be selected. The safety assessment continues to be of the highest priority. Nagra will carry out quantitative safety analyses of the geologically suitable regions named in the plan.

An evaluation of land use and socio-economic impacts is carried out in collaboration with the Cantons concerned and regional consultation bodies. A land use register is prepared that includes existing and future land use and socio-economic background studies are carried out.

At this stage, the regional consultation bodies are given the opportunity to formulate sustainable regional development strategies, or to further develop existing ones.

Nagra designs the layout of the underground sections of the repository and, together with the regional consultation bodies, designates potential sites within the planning perimeter of the geologically suitable regions.

Based on the evaluation of these potential sites, Nagra proposes at least two potential sites each for low-/intermediate-level waste and high-level waste. Some of these sites might be regarded as suitable for all three waste categories.

The sites are then examined by the federal authorities and, if approved, are adopted in the form of intermediate proposals following a three-month consultation period (in accordance with the Swiss Federal Spatial Planning Act) and subsequent approval by the Federal Council.

- Stage 3: Selection of sites and licensing procedures for low-/intermediate-level waste and high-level waste

In the final stage, the remaining sites are subjected to a more detailed examination and, where necessary, the geological data are updated by performing seismic tests and boreholes. This allows in-depth safety assessments to be carried out on a comparative basis in preparation for the licensing procedure. In collaboration with the regional consultation bodies, the project for a deep geological repository is then defined in greater detail and the socio-economic aspects are subjected to closer scrutiny. The regional consultation bodies propose regional development projects. The socio-economic studies also form the basis for monitoring economic and ecological impacts of the geological repository, as well as for any compensation measures. If compensation is foreseen, it is negotiated – and made known – in Stage 3. Nagra then proceeds to propose the location at which the deep geological repository is to be constructed (one site each for low-/intermediate-level waste and high-level waste, or one site for all waste categories).

The work and the activities in Stage 3 also pave the way for the licensing procedure and the first stage of the environmental impact assessment. Stage 3 is completed after the site has been specified in the sectoral plan and the Federal Council has granted a general licence. The next steps concern the approval of the general licence by Parliament and the organisation of a referendum, the latter if an optional referendum is called for against the granting of the licence.



### **Timetable and outlook**

The goal is to put deep geological repositories into operation within 25 to 35 years. High-level waste takes around 40 years to cool down to a temperature low enough to allow for permanent disposal. A large proportion of the low- and intermediate-level waste will only arise after the existing nuclear power plants have been decommissioned and dismantled.

The Federal Council will make its decision on the concept part of the sectoral plan in Spring 2008. This move will create the prerequisites for a broadly based, goal-oriented selection procedure. Nagra will submit its proposals for geologically suitable regions in the course of 2008. The population in these regions concerned will thus, for the first time, be faced with the possibility of a nearby deep geological repository. The submission of the proposals will then lead to the decisive phase of cooperation and participation described above.

Figure 1. Figure 2. **Planning procedure in three stages. Local co-operation plays a major role**

Stage 1

<p><b>Selection of suitable geological sites</b></p> <ul style="list-style-type: none"> <li>- Examination of safety aspects</li> <li>- Status of area planning and specification of assessment methodology</li> </ul>		<p><b>Local co-operation</b></p> <ul style="list-style-type: none"> <li>- Provision of information to involved cantons, municipalities and neighbouring countries</li> <li>- Provision of information to local population</li> <li>- Establishment of intercantonal committee</li> <li>- Formation of regional consultation bodies</li> </ul> <p>- Federal government - Involved cantons, municipalities and neighbouring countries - Entities responsible for waste disposal</p> 
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Stage 2

<p><b>Selection of at least 2 sites</b></p> <ul style="list-style-type: none"> <li>- Provisional safety studies</li> <li>- Finalisation of repository projects</li> <li>- Area planning and environmental aspects</li> <li>- Socioeconomic background studies</li> </ul>		<p><b>Local co-operation</b></p> <ul style="list-style-type: none"> <li>- Periodic provision of information</li> <li>- Intercantonal committee</li> <li>- Regional consultation</li> </ul> <p>- Federal government - Involved cantons, municipalities and neighbouring countries - Entities responsible for waste disposal - Region (population and interest groups)</p> 
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Stage 3

<p><b>Selection of site</b></p> <ul style="list-style-type: none"> <li>- Detailed geological findings</li> <li>- In-depth economic studies</li> <li>- Selection of site</li> </ul>		<p><b>Local co-operation</b></p> <ul style="list-style-type: none"> <li>- Periodic provision of information</li> <li>- Intercantonal committee</li> <li>- Regional consultation</li> </ul>
<p><b>Licensing procedure</b></p> <ul style="list-style-type: none"> <li>- Report on substantiation of site selection</li> <li>- Safety and security reports</li> <li>- Environmental impact statement</li> <li>- Report on compatibility with area planning</li> </ul>		<ul style="list-style-type: none"> <li>- Federal government</li> <li>- Involved cantons, municipalities and neighbouring countries</li> <li>- Entities responsible for waste disposal</li> <li>- Region (population and interest groups)</li> </ul> 

## Societal aspects in Siting a Radioactive Waste Disposal

Jacob Spangenberg<sup>1</sup> and Kaj Nilsson<sup>2</sup>

Mayor of Östhammar, Sweden; Project manager, Oskarshamn, Sweden

 <p>Sweden</p> <p>ÖSTHAMMARS KOMMUN</p> <p>Oskarshamns kommun</p> <p>ÖSTHAMMARS KOMMUN</p> <p>Oskarshamns kommun</p>
<p>ÖSTHAMMARS KOMMUN</p> <p>Oskarshamns kommun</p> <p>Political and legal framework</p> <ul style="list-style-type: none"><li>• Swedish municipalities have – from a European perspective – a high level of independence</li><li>• Main tasks : education, social welfare for elderly and young, kindergarten, planning, environmental protection etc.</li></ul> <p><b>Östhammar</b></p> <ul style="list-style-type: none"><li>• Population of 21 500</li><li>• Annual budget is app 110 M euro</li></ul> <p><b>Oskarshamn</b></p> <ul style="list-style-type: none"><li>• Population of 26 000</li><li>• Annual budget app 120 M euro</li></ul> <p>Both municipalities have experiences of nuclear facilities.</p>
<p>ÖSTHAMMARS KOMMUN</p> <p>The municipality of Östhammar</p> <p>area 2790 km<sup>2</sup> - where of 47% water 4000 km shore line - 1000 islands</p> 





### Decisions made by the Local Council

June 1995

- Acceptance of Pre-feasibility study
- A consultative group was established
- Application to the Nuclear waste fund

Dec 2001

- Acceptance of Site investigation/ feasibility study



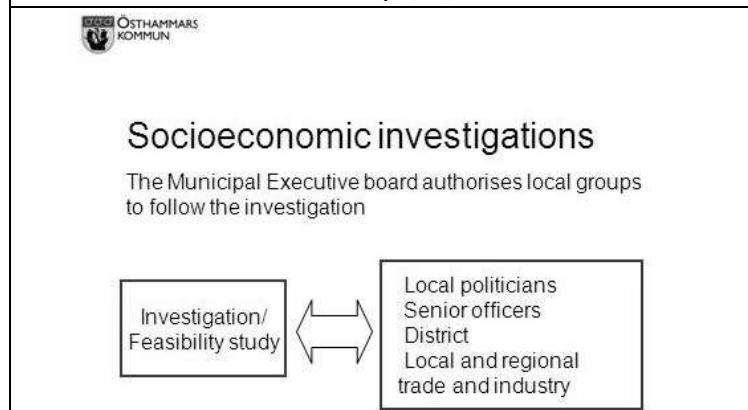
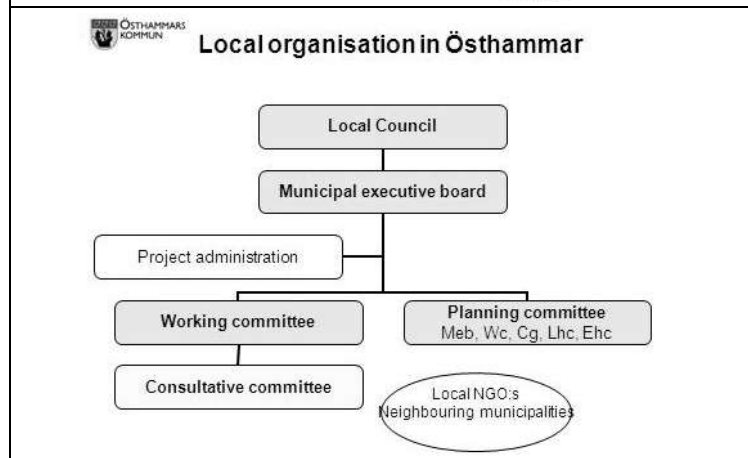
### Main political considerations

- Radioactive safety
- Environmental impact
- Health effects
- Socioeconomic aspects



### Local and regional environment

- The Local politicians will make the final decisions
- Municipal residents needs to have confidence in the overall process
- Neighbouring municipalities and local NGO's must be allowed to participate
- Annual budget for the project organisation is app. 500.000 euros



## Information and Communication

- Brochures, News letters
- Open meetings
- Seminars  
Security, environmental issues,  
ethical issues
- High school information

26 000 inhabitants



The Simpevarp Peninsula, Oskarshamn Sweden



All Swedish spent nuclear fuel is here!

## Oskarshamn-HLW-History

- 1992 announced preferred site for encapsulation plant
- 1995 request for feasibility study
- 1999 feasibility study complete
- 2000 request for site investigation - one of two
- 2002 yes to site investigation and initiation



- A key question - Is a repository safe?
- What impact will a repository have in the municipality?
- How do we establish trust?
- The decision making process



### A well defined decision making process

- Process is as important as content!
- Define the actors and their roles
- Define participation - how and when
- Realise the importance of the regulator
- A local veto empowers the public and the local decision makers. A local referendum?



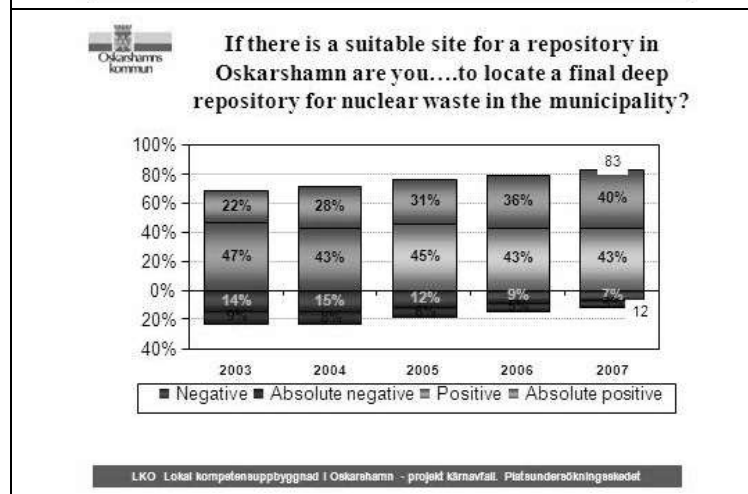
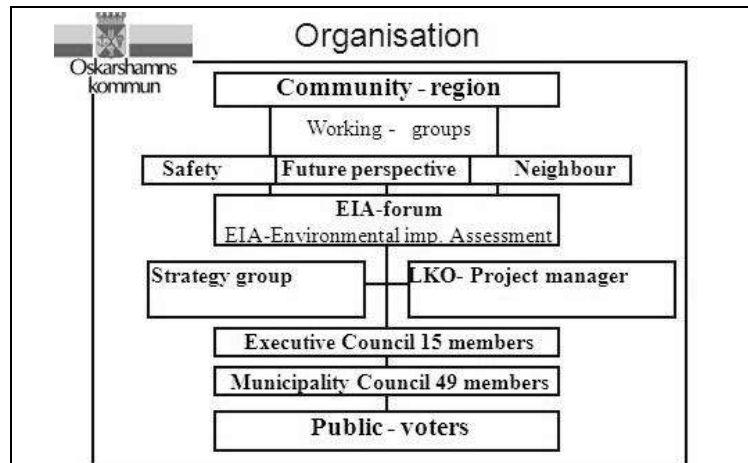
### The importance of an open process

- For the public the project starts when it is put on the map
- Let it take time to bring the public on board
- Realise that there is a lot of local expertise -that can form a better project - if you listen
- Admit uncertainties
- Admit necessity of more R&D



### The Oskarshamn model

- Full openness, participation and influence
- The EIA the legal framework
- The council the local client
- The public a resource
- The environmental groups a resource
- The regulatory authorities our experts
- Stretching of SKB and the regulators



**Conclusion**

The public must get a feeling of trust for politicians, industry, regulators and for the process

- Long time to build trust
- Communicate - participate
- Realistic timetable
- Predictable process
- Openness

## **Overview of EDRAM and of the Canadian Nuclear Fuel Waste Management Programme**

**Kenneth E. Nash**

Chairman, International Association for Environmentally Safe Disposal of Radioactive Materials and  
President, Nuclear Waste Management Organisation, Canada

### **Introduction**

This paper addresses three items: the views of EDRAM, an international organisation of waste management companies; the Canadian spent fuel programme; and a deep geologic repository for L&ILW being developed in Canada.

### **The Views of EDRAM**

EDRAM was formed in 1998 and comprises the CEOs or Chairmen of nuclear waste companies in eleven countries (Belgium, Canada, Finland, France, Germany, Japan, Spain, Sweden, Switzerland, United Kingdom and the United States.). Each company has legislated responsibility for implementing long-term radioactive waste management solutions. I have the pleasure of serving as current Chair of EDRAM.

The main objectives of EDRAM are to:

- Exchange knowledge and experience.
- Promote coordination of research.
- Benchmark and optimise our practices.
- Coordinate input to other international organisations.
- Discuss our individual strategies.
- Support our individual approaches.

When we formed the organisation in 1998, our focus was primarily technical dealing with the first items on this list but as we have matured, our emphasis has shifted towards coordination with international organisations on such things as international safety standards and policies and discussions of strategy. While we recognise the circumstances differ in each country, and this requires individual approaches, there is a high degree of commonality and much to learn from each other.

The strength of the organisation is our commonly held views and the collegial way we operate. Our commonly held views are that we agree:

- The burden and responsibility for taking care of radioactive waste should not be passed on to future generations.
- There is a need for flexibility and open and ethical involvement of stakeholders in decision making.
- Development of long-term solutions should proceed irrespective of the future of nuclear power generation.
- Sound financial provisions are part of this generation's responsibility.
- A stepwise approach to decision making should be made to address the issues involved.
- Management approaches must be customised in each country.

The collegial way in which we operate is partly because we each see ourselves as performing a public good and recognise that implementing public policy in this field has major challenges.

## **The Canadian spent fuel programme**

The Canadian spent fuel programme started thirty years ago and can be viewed in three ten-year segments. The first ten years primarily focused on significant advances on repository technology and ended by a perceived failure in site selection. This resulted in an environmental review of the repository concept which lasted almost ten years. This review concluded that a geologic repository was technically feasible but social acceptability had not been demonstrated.

The last ten years can be characterised as a redevelopment of governance and public policy.

- First by an Act of Parliament.
- Second by the formation of our Nuclear Waste Management Organisation.
- Third by a study of management approaches resulting in a recommendation for Adaptive Phased Management, our plan for long-term spent fuel management.
- Government of Canada approval of NWMO's proposal.

The Canadian plan, Adaptive Phased Management (APM) comprises both a technical method and a management system. The technical method has the end point of a geologic repository with monitoring and retrievability for an extended period of time. Equally important is the management system which requires:

- Phased and adaptive decision making.
- Sustained citizen engagement.
- Continuous learning.
- An open, inclusive and fair siting process.
- Financial surety.

This plan will proceed irrespective of the future of nuclear power.

Reflecting on some other lessons learned in the Canadian programme:

- The first is self-evident. It can take a long period to recover from a failure in siting.
- The second is that the pace of implementation must be consistent with the social licence to proceed.
- We should be aware that societal expectations change. What was acceptable in the eighties was not acceptable in the nineties.
- Capacity and relationship building and collaborative planning are essential.

Looking to the future, we have established seven strategic objectives to guide our planning.

- We will continue to build relationships and develop our implementation plans for a geologic repository in collaboration with others.
- Technical and social research will be advanced.
- Steps will be taken to provide financial surety.
- Plans will be adjusted against evolving societal expectations including changes in energy and environmental policies such as new build nuclear.
- Our governance structure will be further developed to ensure greater transparency.
- Our organisation's capacity will be further developed.

And, of course, we must design and then initiate a siting process.

In moving ahead to formulate specific plans we have several considerations, including the four listed here:

1. Canada has the second largest land mass in the world. This presents both an opportunity and a challenge.
2. Almost all of Canada is of interest to our Aboriginal peoples who have distinct cultural and legal status.
3. We have yet to decide on the appropriate level of capacity in relationship building prior to initiating a siting process; and
4. We expect new build nuclear and the possible entry of Canada into GNEP to have an influence on our work.

### **Management of low-level waste**

I will conclude with a very brief progress report on the deep geologic repository for low and intermediate level waste in Kincardine on the shore of Lake Huron in Ontario. Kincardine is the host of the Bruce Nuclear Power Development comprising eight Candu reactors and an interim storage facility for L&ILW from all of Ontario's 20 reactors. The Municipal Council, in collaboration with Ontario Power Generation, the owner of the Bruce site, developed plans for a geologic repository 660 m deep in a low permeability limestone formation. In fact, it was the Municipality that selected this option after a review of several alternatives. The project is now in the regulatory review phase.

- Recent borehole results are positive confirming that the site is highly suitable for a repository.
- Community support remains very strong.

And finally, I believe it is true to say that a significant part of Kincardine becoming sufficiently confident to host a repository was the dialogue they had with other host communities and with similar facilities in EDRAM member countries. This, of course, is just one more demonstration of the value of international collaboration.



## **The Implementation Process for a Deep Geological Repository for Radioactive Waste in France**

**Marie-Claude Dupuis**

Chief Executive Officer,

French National Radioactive Waste Management Agency, France

### **Research phase**

The management of high-level and long-lived intermediate-level waste has been investigated for 15 years in accordance with the *Law of 1991*. The objective was to provide the government and Parliament with sufficient information by 2006 to proceed forward with a decision concerning radioactive waste management. One of the major aspects was to ensure that alternative solutions had been well explored before a formal stand was made. Investigations were carried out in three areas:

- Partitioning and transmutation of the radionuclides contained in the waste.
- Conditioning and long-term storage of waste.
- Reversible or non-reversible waste disposal in a deep geological formation.

Andra performed studies on waste disposal, while the French Atomic Energy Commission (*Commissariat à l'énergie atomique – CEA*) dealt with partitioning and transmutation, as well as waste conditioning and storage.

In 2005, a comprehensive report covering the entire body of acquired knowledge and results was presented to the government. Partitioning and transmutation appeared promising in order to reduce the volume and intensity of the toxic residues to be produced by nuclear reactors in the future. However, from the standpoint of operational safety, it would be rather difficult to act efficiently with regard to any radioactive waste that already exists or is currently being produced. Research on waste conditioning has helped to confirm the long-term sustainability of waste packages and to develop behaviour models under storage and disposal conditions. Storage may be guaranteed for 100 years through existing industrial facilities. New designs may also be contemplated, probably in subsurface installations, depending on the specific characteristics of the sites. However, the requirement for responsible management by the generation that produced the waste does not allow storage to be considered as a satisfactory ultimate solution.

Over the 15 years of research, studies on the feasibility of a reversible deep geological repository for radioactive waste focused gradually on Callovo-Oxfordian argillites and, to a lesser and more generic degree, on granite. Although the results were encouraging, no concrete prospect was identified for a repository within a granite formation in France. Investigations on argillites were first conducted from the surface and later from the underground laboratory excavated at the Meuse/Haute-Marne site at Bure. Results confirmed the potential of the research area around the laboratory and helped delineate a 250 km<sup>2</sup> so-called “zone de transposition” in which similar results could be obtained.

### **Result assessment**

Investigations were followed up on a regular basis first by the National Review Board (*Commission nationale d'évaluation – CNE*) and later through a scientific assessment of results. The *Dossier 2005* prepared and submitted by Andra on deep geological disposal was also reviewed by the Nuclear Safety Authority (*Autorité de sûreté nucléaire – ASN*). Lastly, at the government's request,

an international peer review was organised by the OECD Nuclear Energy Agency (OECD/NEA), which praised the *Dossier 2005* for the quality of its information and analyses. It was emphasised that the work met the best international standards and that a deep geological repository proved feasible. The reversibility principle in response to a statutory requirement for a precautionary approach, as recommended by policy makers, was considered innovative at the international level and would not compromise the safety of the repository. Relevant authorities that reviewed the *Dossier 2005* also formulated a series of recommendations regarding the need for further research. Priorities include radionuclide migration, the excavation disturbed zone (EDZ) and the behaviour of gases. The construction of so-called “demonstrators” designed to materialise and test the various equipment was also requested. Lastly, over and above scientific and technical aspects, the need for a better account of social and economic issues was advocated.

At the end of this important research stage, the Parliamentary Office for Science and Technology Assessment (*Office parlementaire pour l'évaluation des choix scientifiques et technologiques* – OPECST) also analysed suitable management strategies to be implemented. Within a long-term prospect combining radioactive waste and energy management, the need for a deep geological repository was stressed, while recommending that relevant studies be furthered with a view to reducing the volume and toxicity of the waste.

Furthermore, the public debate organised between September 2005 and January 2006 by the National Commission on Public Debate (*Commission nationale du débat public* – CNDP) helped to refine the overall view of the various expectations. Besides claims related to nuclear power generation, specific requests have also emerged concerning the integration of all waste categories within a consistent management policy, the improvement of governance and the creation of incentive measures in support of the repository project in terms of regional development.

An advisory constitutional assembly, called the Economic and Social Council (*Conseil économique et social*), published its opinion in March 2006 and specified that proposals were “*necessary for sustainable management of radioactive materials and waste. Such management refers to our responsibility towards current and future generations, and primarily to the State in accordance with its mission, to ensure sound management that is not only based on science, but is also transparent and democratic.*”

On 22 March 2006, the available body of information and opinions led the government to table a bill before Parliament. Planning Act No. 2006-739 Concerning the Sustainable Management of Radioactive Materials and Waste (Loi n° 2006-739 du 28 juin 2006 de programme relative à la gestion durable des matières et déchets radioactifs) was adopted and later promulgated on 28 June 2006.

### **Planning Act of 28 June 2006**

The *Planning Act of 28 June 2006* deals with all radioactive waste and materials and relies on the following three principles:

- Reducing the volume and toxicity of radioactive waste, especially by treating or conditioning spent fuel and waste.
- Storing all radioactive materials pending treatment and all radioactive waste pending disposal in specifically dedicated installations.
- After storage, disposal in a deep geological repository of all radioactive waste that is unsuitable for disposal in surface or shallow facilities for nuclear safety or radiation protection reasons.

The programme described in the act includes objectives relating to storage, disposal and transmutation. Storage is already an industrial reality and investigations and studies concerning

storage continue with a view to creating new facilities or modifying existing ones in order to meet needs, especially in terms of capacity and sustainability. Investigations and studies on deep geological disposal also continue in order to select a suitable site and to design a reversible repository within a deep geological formation in time for a licence application to be reviewed in 2015 and for the repository to be commissioned in 2025. Ongoing research on advanced partitioning and transmutation involves the Generation IV Programme and must lead to an assessment of industrial prospects by 2012 and the commissioning of a prototype facility by 2020.

The role and independence of the CNE are confirmed and its jurisdiction has now been extended to social issues.

A Local Information Committee (*Commission locale d'information* – CLI) is entrusted with a broader mission and funded with secured provisions. The Committee is chaired by a member appointed by the respective presidents of the General Councils of the districts which lie within the perimeter of the underground laboratory.

The decision to implement the potential repository will not be made until the results of the ASN review are published, a public debate and enquiry have been held and a consultation with the communities has taken place.

Funding for research and regional development are guaranteed through the collection of two new taxes. Lastly, waste producers are required to constitute advance funds for the dismantling of their facilities and the management of their radioactive waste through the provision of secured assets, as follows:

- Industrialists assess the corresponding costs, constitute provisions and allocate assets consistent with suitable security and liquidity levels.
- Assets are controlled by public authorities; they are dedicated exclusively to the financing of these costs and nobody else may use them for any other purpose.

### **Programmes in support of the licence application for a deep geological**

The relevant programmes undertaken in order to meet the deadline concerning the review of the licence application for the implementation of the deep geological repository by 2015 were integrated within a national development plan describing Andra's research and study strategy. The new *Planning Act* also requires that a public debate be held before the submission of the licence application. This debate must be designed with a view to facilitating the future decision-making process, especially with regard to the draft law on reversibility conditions to be prepared by the government after the licence application for the implementation of the deep geological repository has been reviewed technically. The major deadlines mentioned in the development plan include:

- 2009:
  - Description of design, safety and reversibility options.
  - First step towards the selection of a suitable site, including the delineation of a 30 km<sup>2</sup> restricted zone in order to propose a site later.
- 2012:
  - Submission of a report in support of the public debate and the site selection.
  - Presentation of so-called “technological demonstrators” and a study constituting a preliminary project brief.
  - Transmission to assessors of the first elements in preparation for the licence application for the implementation of the deep geological repository.

- 2013:
  - Public debate on the repository project.
  - Selection of a disposal site.
- 2014:
  - Submission of the licence application for the implementation of the deep geological repository, including a description of the proposed installations.
- 2015:
  - Views of local communities concerning the licence application for the implementation of the repository.

The overall process is designed to allow for a new law on reversibility conditions to be voted on and for the deep geological repository to be commissioned in 2025.

## **Implementation of the Swedish Concept for Deep Geological Disposal**

**Claes Thegerström**

President, Swedish Nuclear Fuel and Waste Management Company, Sweden

### **Introduction**

The nuclear power industry was given the responsibility for management and disposal of all radioactive waste from its plants back in the 1970s. The owners of the nuclear power plants therefore jointly formed SKB, the Swedish Nuclear Fuel and Waste Management Company. A fund to finance the programme was set up a few years later. SKB was given the task of organising the work of disposing of the waste. Over the past three decades, we have built up a system for disposing of different types of radioactive waste in a safe manner.

### **The system in operation**

SKB has now developed a system that ensures the safe handling of all kinds of radioactive waste from Swedish nuclear power plants for a long time to come. The cornerstones of the system that is now in operation are:

- A transport system with M/S Sigyn, a specially built ship for transporting the waste, which has been in operation since 1982.
- A central interim storage facility for spent nuclear fuel (CLAB) in Oskarshamn, which has been in operation since 1985.
- A final repository for short-lived, low- and intermediate-level waste (SFR) in Forsmark, which has been in operation since 1988.

Since the start-up, this system has fulfilled its task in a safe and satisfactory manner.

### **Research, development and demonstration**

Some important components are, however, lacking in order for the system to be complete. Most important are the facilities required for final disposal of the spent nuclear fuel. The Swedish method for disposing of spent nuclear fuel is called KBS-3. Since the 1970s, we have been working with the development of the method, which has become increasingly refined. It is based on the use of multiple protective barriers to isolate the fuel. The KBS-3 method entails encapsulating the spent nuclear fuel in copper canisters, which are embedded in bentonite clay at a depth of about 500 metres in the Swedish crystalline bedrock.

Much of the research and development for encapsulation and final disposal of spent nuclear fuel needs to be done on a full scale and in a realistic setting. SKB has therefore built a number of laboratories to carry out different research and development projects. Four R&D facilities should be mentioned:

- The Stripa mine, about 250 km west of Stockholm, was leased by SKB in 1976 when the ore reserves were exhausted. SKB started in situ experiments there to provide technical data for evaluating the suitability of granite for disposal. In the same year, the Swedish-American Cooperative (SAC) programme was established between SKB and the US Department of Energy for the time period 1977 to 1980. The International Stripa Project, which started in 1980 and ended in 1992, was conducted under the auspices of the Nuclear Energy Agency

(NEA), with the objective to investigate several aspects of technology concerned with the feasibility and safety of disposal of long-lived, heat-generating radioactive waste at depth in granitic rocks.

- The Äspö Hard Rock Laboratory, which was built during the period 1990-1995, is situated at Äspö, north of the Oskarshamn NPP. The purpose of the HRL is to enable research, development and demonstration to be done in a realistic and undisturbed rock environment down to repository depth. The underground laboratory consists of a tunnel with a total length of 3 600 metres. Along this, we are conducting research and technology development on a full scale and in a realistic setting. Both technology-oriented experiments and scientific research are being pursued in the Äspö HRL, in cooperation between Swedish and international experts. The laboratory will serve as an important training facility during the construction of the final repository for spent fuel.
- The Canister Laboratory, situated in the Oskarshamn harbour area, was built during the period 1996-1998 to support the development of sealing technology for the copper canisters. It is used mainly for the development of equipment for welding of copper lids and bottoms and for non-destructive testing of the welds. Equipment and systems for handling of fuel and canisters in the future encapsulation plant are also tested and developed in the Canister Laboratory. Another purpose of the activities is to train personnel for commissioning of the encapsulation plant.
- The Bentonite Laboratory was built close to the underground Äspö HRL during 2006. SKB will investigate how the buffer material will behave in the final repository. The new laboratory enables full-scale experiments under controlled conditions. The Bentonite Laboratory makes it possible to vary the experiment conditions in a manner which is not possible in the rock.

### **Facilities to be built**

The development of the KBS-3 method has been carried out in parallel with work to find a suitable site for the final repository. SKB reported on feasibility studies in 2000, together with a proposal for further investigations at some sites. The Government gave the go-ahead for further investigations in 2001 and, in 2002, we started site investigations in the municipalities Oskarshamn and Östhammar after confirmatory decisions by the municipality councils. The site investigations have now been going on for five years and drilling has just been concluded. An intensive period will now follow when all results are analysed and evaluated and eventually compiled into the permit application for the site that will be chosen. In addition to the final repository, we also have to develop a canister factory and build a plant for encapsulation of the spent fuel.

SKB plans to file the permit application for the final repository within a few years. It will be scrutinised by the regulatory authorities and reviewing bodies. Provided that the permit is then issued, construction could start around 2012 and the first canister could be disposed of in 2020.

Meanwhile, in November 2006 we applied for a permit to build the encapsulation plant adjacent to the present CLAB interim storage facility in Oskarshamn. The new facility will employ unique technology, including a friction stir welder for attaching the lids to the copper canisters in which the spent nuclear fuel will be placed. According to plans, the construction of this facility will also start in 2012.

SKB performs safety assessments regularly. In these we study what long-term effects the system for spent nuclear fuel, with a repository as the centre, will have on man and the environment. The analysis helps us to prioritise the development efforts by showing us where there is need for further efforts.

When we apply for permits to build the final repository, the safety assessment is an important supporting document. Our most recent safety assessment, called SR Can, was published in connection with the permit application for the encapsulation plant. This safety analysis is now under broad national and international review and all aspects that are raised during this process will be taken care of in the next safety assessment, in connection with our planned permit application for the final repository.

### **Support for a development process**

The Swedish programme has evolved over the past 30 years in consensus between the nuclear power utilities and political interests. I want to especially mention three important principles behind this national mobilisation:

- The first is a regulated step-wise implementation process. Since the middle of the 1980s, SKB has submitted an RD&D Programme every three years for the Government's approval. Before the Government makes a decision, the Programme is circulated and scrutinised in a broad review, which involves government authorities, research institutions and environmental organisations. This process allows recurring reviews of the implementation work and gives all interested parties the possibility to examine our work and to express their opinions about it. The picture shows SKB's Programme reports, from the first report in 1984 to the last report, which was issued two weeks ago on 28 September 2007.
- A second important principle is a clear division of roles. The nuclear power utilities – the producers – are responsible for management of the waste. This responsibility is determined by law and its implementation is in fact required to obtain and keep the licence to run the power plant. SKB is owned by the nuclear power companies and has been given the responsibility for waste management and finding a method and site for final disposal. The regulators review SKB's programme and work to make sure it meets the requirements on safety and radiation protection.
- The third important principle is that of organised local consultation. This is a legal obligation in the siting process according to the Environmental Code, but SKB started a broad consultation process already in the early 1990s. One very important contribution to the consultation process has been that the concerned local municipalities set up formal review teams with the explicit task of scrutinising and assessing SKB's proposals. The municipal review teams were given the mandate to question SKB's work and to request supplementary studies and investigations.

We feel that the long period of dialogue with the local residents has generally led to trust in our work. SKB has occasionally commissioned opinion polls on people's attitudes towards a deep repository. One of the clearest tendencies is that people with the most knowledge about SKB and the deep disposal method are the ones who are the most positive. This is particularly clear in the municipalities where we perform investigations and where the issue has been discussed for a long time. Four out of five of the people in Oskarshamn and Östhammar are in favour of building a deep repository if a suitable site can be found in their municipality. This is confidence in our project that must be maintained.

### **From thought to action**

The Swedish nuclear fuel disposal programme is now close to taking the first decisive step from theory to practice. For a long time now, we have been devoting most of our resources to the development of this crucial component in the waste management system. We have built four laboratories to test and demonstrate our method on a full scale. At the same time, we have worked intensively to find a site for the repository, one with suitable bedrock and a local population that accepts the repository.

We will now reach the end of this stage. Step by step, we are proceeding from thought to action and we now have to take up a major challenge. After decades of extensive work on research, development and demonstration, we will now have to work out and design all the site-specific facilities and systems. In the permit applications, we must specify the technical solutions we intend to apply and show that they will work in the mining environment that a repository represents.



## **The Management and Disposal of Spent Nuclear Fuel and High-level Radioactive Waste in the United States**

**Edward F. Sproat III**

Director, Office of Civilian Radioactive Waste Management, U.S. Department of Energy, USA

The management and disposal of spent nuclear fuel and high-level radioactive waste in the United States (U.S.) has a long history, dating back to the 1950s following the first nuclear weapons production in 1945. This presentation by the Director of the Office of Civilian Radioactive Waste Management (OCRWM), who is responsible for the Yucca Mountain Project, describes the important milestones of the programme including past, current, and future activities which will ultimately lead to the receipt of spent nuclear fuel and high-level radioactive waste for disposal at the Yucca Mountain site in 2017.

In 1953, President Dwight Eisenhower when addressing the United Nations General Assembly in his “Atoms for Peace” speech, called on all leaders to move toward peaceful uses of nuclear technology. Following that address, the U.S. Congress passed the Atomic Energy Act of 1954, directing the Federal Government to promote the peaceful use of atomic energy, with the understanding that disposal of the highly radioactive waste produced would be the responsibility of the Federal Government.

For over 60 years, the United States have produced spent nuclear fuel and high-level radioactive waste through a variety of activities, including commercial electric power, defence-related activities, and research and development. The high-level radioactive materials produced or used in these processes have accumulated at more than 120 sites in 39 states.

In 1957, the National Academy of Sciences recommended deep geologic disposal of the long-lived highly radioactive wastes from nuclear reactors. Over the years, scientific studies world-wide have reached the same conclusion.

The search for suitable sites for geologic disposal of these wastes had begun as early as the 1970s. In the same time frame, reprocessing efforts in the United States were halted by President Jimmy Carter for economic and policy reasons. This left no clear disposition path for spent fuel accumulating in storage pools at reactor sites. The Nuclear Regulatory Commission was prompted to study whether nuclear reactors could continue to operate with confidence that the spent fuel could be safely stored at the reactors and would in due course be disposed of safely.

In 1978, President Carter established an Interagency Review Group to review national radioactive waste management policy, which confirmed the consensus that geologic disposal was the most promising technology for permanent disposal of high-level radioactive waste and spent fuel. It also recommended that a national repository siting programme should consider at least two repositories, preferably in different regions of the country.

The 1980s saw a profusion of important developments in the waste disposal programme. The repository siting process was sharply focused as a result of the passage of the Nuclear Waste Policy Act (NWPA) in 1982, which established policy to govern development of a Federal radioactive waste management system. The NWPA established the U.S. government’s responsibility and policy for managing spent nuclear fuel and high-level radioactive waste. It directed the U.S. Department of Energy (DOE) to select possible sites around the country for study as locations for two potential repositories, and

limited the amount of waste that could be placed in a first repository to 70 000 metric tons. The NWPA also established a schedule leading to federal waste acceptance for disposal; established the Nuclear Waste Fund to pay for the waste programme with fees collected on the generation of electricity from nuclear power plants; and required that the repositories be licensed by the Nuclear Regulatory Commission using environmental protection standards set by the Environmental Protection Agency.

The DOE in 1983, identified nine potentially acceptable sites – six in the western part of the U.S. (four in bedded salt, one in basalt, and one in tuff) and three (all in domed salt) in the south. In 1984, DOE issued final Siting Guidelines as required by the NWPA and published draft environmental assessments (EAs) on all nine sites, followed by final EAs on five sites in 1986 (three in salt formations and one each in basalt and tuff). DOE recommended three of those five sites in 1986 for characterisation – basalt at Hanford, Washington; tuff at Yucca Mountain, Nevada, and salt at Deaf Smith County, Texas.

In parallel, a “second round” of siting efforts for a second repository was ongoing, focusing on crystalline rock in the eastern U.S. to comply with the requirement for a regional distribution of repositories. DOE conducted a screening in 17 states, and selected 12 sites in 7 states on the east coast and in the upper Midwest.

At the time the 3 candidate sites for the first repository were recommended in 1986, DOE deferred the search for a second repository site. In 1987, Congress passed the Nuclear Waste Policy Amendments Act, which directed DOE to discontinue studying all other sites, and to study the tuff site at Yucca Mountain, Nevada exclusively to determine its suitability as a potential repository. The Yucca Mountain site is located 100 miles northwest of Las Vegas in Nye County, Nevada, on federally-owned land on the western boundary of the Nevada Test Site, which is a DOE facility approximately the size of the state of Rhode Island. The Amendments Act also required DOE to deliver a report on the need for a second repository between 2007 and 2010. In addition, the Act also established a Review Commission to review the need for a monitored retrievable storage (MRS) facility and established an Office of the Nuclear Waste Negotiator to seek volunteer states or Indian Tribes to host an MRS or repository. The Negotiator was unable to reach agreement with any potential hosts, and congressional authorisation for the office expired.

After several years of site characterisation, Congress, in 1996, directed DOE to prepare a Viability Assessment of the Yucca Mountain site. The purpose was to present an informal assessment of the viability of licensing and constructing a geologic repository at the Yucca Mountain site. Although the viability assessment was not a formal site recommendation required by the NWPA, it was a step in a process of study and evaluation of the site. The assessment concluded that the Yucca Mountain site had no “show stoppers” and that work should continue. In August 2001, DOE issued a preliminary site suitability evaluation that found Yucca Mountain could meet EPA and NRC requirements.

Following the provisions of the Nuclear Waste Policy Act, the Secretary held public hearings in the state of Nevada in the fall of 2001, and informed the state of his intention to recommend the Yucca Mountain site to the President as suitable for development of a repository. In February 2002, the Secretary of Energy recommended the site to the President, and submitted the final Yucca Mountain environmental impact statement and supporting materials. The next day, the President recommended the site to the U.S. Congress as qualified for an application to authorise construction of a repository at the site. In July 2002, Congress overturned a notice of disapproval by the state of Nevada, and passed a joint resolution designating the site as the potential national repository for high-level radioactive waste, allowing DOE to begin preparations for a License Application to the U.S. Nuclear Regulatory Commission.

In 2006, DOE adopted a revised approach to repository design, development, and operation. Central to this approach is the use of a canister concept for commercial spent fuel that minimises the handling of individual spent fuel assemblies, limits the need for complex surface facilities, and simplifies repository design, licensing, construction, and operation. A transportation, aging, and disposal (TAD) canister would be used to transport, age, and dispose of spent fuel without the canister ever being reopened, thereby simplifying and reducing the number of handling operations involved in packaging commercial spent fuel for disposal. The canistered approach also offers the advantage of using practices familiar to the nuclear industry and the U.S. Nuclear Regulatory Commission (NRC), thereby making the repository easier to design, license, build, and operate. DOE is currently finalising design and procurement processes for the TAD canisters.

DOE is also planning the infrastructure required for a national transportation system that will safely and efficiently transport spent fuel and high-level waste from all over the country to the Yucca Mountain site. In addition, DOE is planning to construct a new rail line within the state of Nevada, connecting existing commercial rail lines to the Yucca Mountain Site.

In October 2007, DOE issued two draft supplemental environmental impact statements evaluating potential national and Nevada transportation routes. DOE also issued a draft supplemental environmental impact statement for Yucca Mountain, which analyses the potential impacts of the current repository design and operational plans, including transportation plans. Analyses include the 70 000 metric ton waste inventory as limited by the NWPA, as well as a projected total final inventory of 130 000 metric tons. These analyses are expected to be finalised in May 2008.

Also in October 2007, in preparation for submittal of the license application, DOE certified its document collection for the Nuclear Regulatory Commission's Licensing Support Network (LSN). As the license applicant, DOE is required to make available on the LSN material relevant to the licensing proceeding no later than six months in advance of the submittal of the application.

DOE plans to submit the license application to the NRC by June 30, 2008, for construction of a repository at Yucca Mountain, Nevada, for the disposal of the nation's spent nuclear fuel and high-level radioactive waste. The license application will include the design and safety analyses for all planned repository facilities, and will allow for a period of monitoring and waste retrievability of at least 50 years after final emplacement of waste before final closure of the repository. Completion of repository construction is envisaged by the year 2016. The NRC will grant a construction authorisation only if it determines that the repository would meet its reasonable expectation that the safety and health of workers and the public would be protected. Assuming a construction authorisation is granted and construction substantially completed, the NRC will then determine whether to authorise DOE to begin to receive and possess spent fuel and high-level waste for disposal in the repository.

These future milestones, which would lead to the start of repository operations in 2017, are based on a best achievable schedule and are dependent upon funding appropriations, timely issuance of all necessary authorisations and permits, the absence of litigation-related delays, and enactment of proposed legislation supported by the Secretary of Energy. This legislation is important for meeting future funding requirements and mitigating the increasing costs to taxpayers from delay in repository operations. The critical need for Programme funding reform would make it possible to use the Nuclear Waste Fund and nuclear waste fees. The proposed legislation would also address issues such as repository regulatory requirements, the statutory 70 000 metric-ton capacity limit, infrastructure development, and interim waste storage for future new reactors.

## **The Perspective of U.S. NRC**

**Dale Klein**

Chairman, U.S. Nuclear Regulatory Commission, USA

I am delighted to be here in Berne for this important conference to discuss progress and challenges in geological disposal. Although geological disposal presents unique and long-term challenges, we only have to look around this beautiful city to see that society can opt to preserve, over the long term, important monuments according to societal decisions.

Founded in 1191, I am told the citizens of this city have preserved the townscape intact over the centuries. I am sure the founders did not do a performance assessment to understand the many challenges the town might face over the centuries, but generations of interested caretakers have ensured its survival. Clearly, a high-level radioactive waste repository presents different challenges. But while each of us seeks to ensure a safe and secure long-term solution to the disposal of high-level radioactive, we may pursue multiple paths or approaches that reflect our different national needs and cultural values.

I know that we have been asked to keep our presentations short, so let me address two topics briefly. First, I would like to update you on the Yucca Mountain license application, and then let me put forth for your consideration some reflections on long-term international efforts for cooperating on geological waste disposal issues.

As you know, the U.S. Congress has directed that the NRC will serve as an independent regulator to ensure that any repository adequately protects health and safety and the environment. The Environmental Protection Agency, on the other hand, has the legal responsibility to develop a dose-based standard for a potential Yucca Mountain repository. The initial EPA standards were challenged – and mostly upheld – in court, though the court did require several modifications. We expect that the EPA will soon issue its final regulations and, fairly quickly thereafter, the NRC will issue corresponding regulations to be in accordance with the EPA. This will all be done through an extensive public rulemaking process.

We understand that the DOE intends to submit a license application for a repository at the Yucca Mountain site by June of next year. Thus, we are now in the midst of preparing for an important transition – from the pre-licensing role to the role of regulatory and licensing authority. If the Energy Department submits a license application next year, the NRC will then conduct a staff review and a public administrative hearing as a basis for deciding whether to issue a construction authorisation.

While the NRC will be rigorous in making an independent and objective evaluation, I want to take a moment to stress that independence does not – and should not – imply that the regulator works in isolation. We are committed to ensuring that regulatory issues that affect the safety of a potential repository are raised and addressed early in public forums. Throughout the pre-licensing period, we have sought frequent, constructive and open interactions with all stakeholders, including the DOE, the nuclear industry, the international technical community, State, county and other affected units of local government, affected Native American Tribes and others.

For many years, the NRC has prepared for this review by conducting independent experimental and analytical work through the Center for Nuclear Waste Regulatory Analyses at the Southwest Research Institute in San Antonio, Texas. The experts at the Center are free of conflict of interest and will provide an important technical resource in support of the NRC staff in its review of the application.

In short, we are ready.

Let me now say a few words on my second point: the prospects for enhanced international cooperation on geological disposal. Clearly, the prospects for an international repository programme are too far off to be contemplated today. Nevertheless, it seems to me that we can begin laying the groundwork for more cooperation, so that the possibility of such international repositories could be contemplated in the future consistent with the laws and policies of each nation.

One of the most promising international efforts currently under way is the Multinational Design Evaluation Program, or MDEP. As you may know, over the last year, the U.S. and nine other nations have been working to leverage knowledge and experience on power plant design and promote global convergence in associated codes, standards and regulations – recognizing that each nation will remain responsible for its own regulation and oversight. For its part, the NRC has supported this effort because we believe it will enhance safety and effective regulation and oversight. It is my hope and belief that we can build on the work of MDEP to extend this international cooperation to other parts of the fuel cycle... including waste forms.

Not every nation, of course, will choose to adopt identical waste canisters. But I think that there is ample opportunity for us to work towards common approaches for the certification of waste forms, with measurable standards for waste forms, packages and containers... again recognising that each nation will apply and impose standards and requirements consistent with its own laws and policies.

We know that reactors and other fuel cycle facilities present very significant and large-scale design challenges, while geological repositories will be subject to natural variations from site to site. By comparison, I think it may be somewhat easier to find common approaches to waste packaging standards. Since we already do this in the area of transportation, I think we could all benefit from developing regulatory approaches for waste forms and packages that would qualify for disposal under a variety of national licensing regimes. In fact, these common approaches are probably the only sure foundation for building confidence towards international repositories over the long term.

Of course, in this area as in others, each of our nations has different needs and is at a different stage in the process of selecting a path for managing high-level waste. So let me close by reiterating that the U.S. recognises and appreciates the concept of “A Common Objective, A Variety of Paths” that is the theme of this conference.

Some of us have large nuclear programmes – others have small nuclear programs or have opted to move away from nuclear energy. Some of us are exploring new technologies which could, in the future, reduce the volume of high-level waste needing underground disposal.

The choice of ultimate disposal solutions, however, is independent of the future of nuclear power: high-level waste and spent fuel exist today and we must all pursue a safe, secure and timely solution to disposal. It is important to play an active role in listening and communicating with our stakeholders and to recognise that our societal and cultural values may lead us in a variety of paths. Through this approach, I believe we can be successful in achieving our common objective of protecting public health and safety.

Thank you.

## **Regulatory Aspects of Radioactive Waste Disposal – the Finnish Approach**

**Jukka Laaksonen**

Director General, Radiation and Nuclear Safety Authority (STUK), Finland

### **Finnish nuclear energy programme**

Four nuclear power plant units are currently in operation in Finland: the Loviisa NPP has two 488 MW(e) VVER units and the Olkiluoto NPP has two 860 MW(e) BWR units. These NPP units have been in operation for 26-30 years.

Construction of a fifth reactor, an EPR of 1 600 MW(e) to be located at the Olkiluoto site, started in early 2005.

Two applications for a Decision in Principle (to be made by the Government), which is the first step in licensing of a new nuclear facility, are planned to be submitted in 2009, each for an additional NPP unit.

### **Earliest plans concerning management of spent nuclear fuel from the Finnish NPPs**

The decisions on constructing the current NPPs in Finland were made in late 1960s-early 1970s. At that time, the prospects for nuclear energy were very promising and spent fuel was regarded as an asset due to the worth of its plutonium and uranium as nuclear fuel. Accordingly, the contract for the supply of the Loviisa NPP included clauses for the return of the spent fuel to the supplier of the fresh fuel in the Soviet Union. The price of the spent fuel was agreed to be zero, but moderate transport costs were borne by the Loviisa NPP. Although no stipulations on spent fuel were included in the supply contracts for the Olkiluoto NPP, it was understood as clear that the operator would later make a contract with a French or British reprocessing company.

However, the prospects changed in the mid-1970s. The western reprocessors substantially increased their prices and adopted a contractual stipulation for the return of reprocessing wastes to the generator of the spent fuel. This implied that commercial reprocessing services were no longer an attractive option for a country with no fuel cycle industry such as Finland. Consequently, the licensee of the Olkiluoto NPP, while following prospects in the reprocessing area, opted for extended interim storage of spent fuel and launched preliminary spent fuel disposal studies.

### **Evolution of national policy and arrangements for spent fuel management**

The national spent fuel management policy was formulated in the Government's decision in 1983, stating: In dealing with spent fuel, international central repositories should be made use of where possible because the total amount of spent fuel arising from the operation of domestic nuclear power plants will remain small. The aim continues to be achievement of contractual arrangements through which the reprocessing waste or spent fuel can be transferred and disposed of irrecoverably outside domestic territory. However, in the case of spent fuel for which this kind of contractual arrangement is not achieved, the licensees must be prepared for carrying out final disposal in Finland in a safe and environmentally acceptable way.

The Government decision also established a schedule for the development of a spent fuel repository, to be followed in case the primary goal could not be met. The disposal site was to be selected by the year 2000, construction of the repository would start around 2010 and disposal would start around 2020.

This policy, with its primary and secondary goals, remained valid until the mid-1990s. The licensee of the Loviisa NPP had contractual arrangements for the return of spent fuel and, between 1981 and 1996, about 330 tU of spent fuel was shipped to the Mayak facilities in the Southern Urals. The licensee of the Olkiluoto NPP could not find any satisfactory contractual arrangement and started a programme for direct spent fuel disposal in Finland, including site investigations. The interim storage capacity for spent fuel at Olkiluoto was extended by building an on-site pool-type facility. The operating experience with Finnish wet interim storage for spent fuel has been good and there are no plans to switch to dry storage.

A new policy was formulated in 1994 by the amendment of the Nuclear Energy Act, stating (note that, by definition, nuclear waste includes also spent fuel): *Nuclear waste generated in connection with, or as a result of, the use of nuclear energy in Finland shall be handled, stored and permanently disposed of in Finland. Nuclear waste generated in connection with, or as a result of, the use of nuclear energy elsewhere than in Finland shall not be handled, stored or permanently disposed of in Finland.*

One reason for the policy change was that Finland joined the European Union in 1995 and there were concerns that Finland, having an advanced nuclear waste disposal programme, might be compelled to accept nuclear waste from other EU countries. Furthermore, Finnish politicians were not convinced that nuclear waste was properly managed at the Mayak facility in Russia where the fuel had been reprocessed until then. Environmental problems around the Mayak facility, that actually resulted from earlier nuclear weapons programmes by the former Soviet Union, were frequently reported in the news media and these reports also resulted in foreign political pressure to stop sending spent fuel to Russia.

The new policy led to collaboration between the licensees of the Olkiluoto and Loviisa NPPs and, in 1995, they founded a joint company, Posiva Oy, to continue the spent fuel disposal programme.

The main principles for developing nuclear waste management in Finland are the following:

1. We must not leave nuclear waste as a burden to future generations.
2. We must take steps to ensure safe disposal of nuclear waste and spent fuel using today's proven technology.
3. We must be able to manage our nuclear waste without the need to rely on foreign support.

### **Licensing and regulatory authorities in Finland**

Licensing of nuclear facilities in Finland has three separate steps. The first one is a political decision by the Government, called the Decision in Principle (DiP). The content of the Decision is simply that *“the new nuclear facility is in line with the overall good of society,”* and it has to be endorsed by Parliament before it enters in force. Major investments are permitted only after Parliament's endorsement. The other two steps are the construction licence and the operating licence, both of which are issued by the Government. These steps have never involved further political consideration, but have been more or less technical decisions made when the respective project has reached the specified preparedness. In all steps, the Ministry for Trade and Industry provides administrative support to the Government by processing the licence applications. The Ministry collects and summarises all formal statements and views of the involved authorities, expert organisations and stakeholders and also arranges public hearings on the proposed sites to record public views. Finally, it prepares the text of the licence decision, including the applicable conditions.

STUK is the independent regulatory authority responsible for oversight of nuclear and radiation safety. It drafts all mandatory nuclear safety regulations that are then issued as Government Decrees. More detailed guidance for applying the regulations is given in regulatory guides (called “YVL guides”) issued by STUK. In each licensing process, a favourable safety appraisal by STUK is a necessary condition for issuing the licence. After a licence has been issued, it is the task of STUK to verify through inspections that the required safety arrangements have been made and that the facility remains safe and in compliance with licence conditions over the plant lifetime. STUK also conducts all required inspections on nuclear waste management and nuclear materials safeguards.

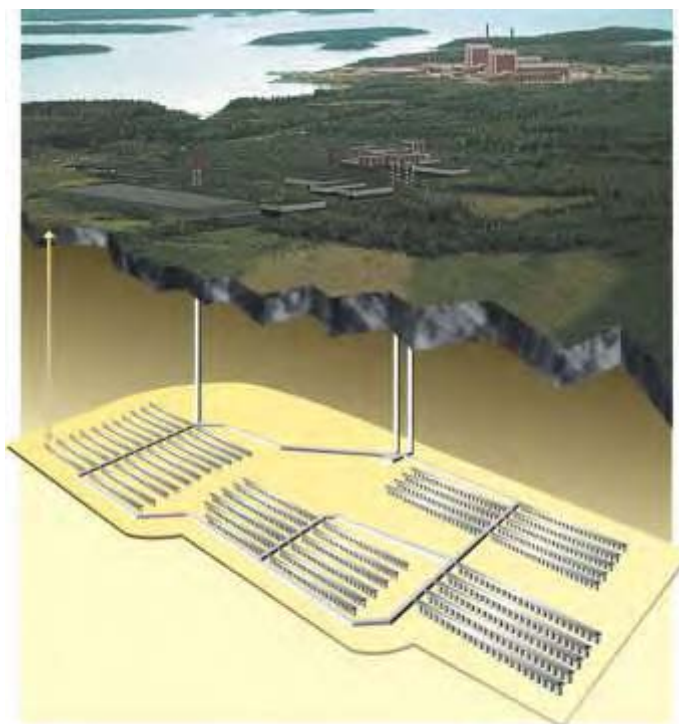
### **Spent fuel disposal programme and the safety concept**

The Finnish spent fuel disposal programme has so far progressed in accordance with the target schedule established in the Government’s policy decision of 1983. A site screening report was published in 1985 and the site investigations started a couple of years later. Six sites were subjected to deep boreholes and other surface-based investigations, two of them being the NPP sites Olkiluoto and Loviisa. The final choice, involving e.g. environmental impact assessment (EIA) processes, was made between four sites. Of these, Posiva Oy selected the Olkiluoto site as the preferred disposal site in 1999.

Posiva submitted its DiP application for constructing a spent fuel disposal facility at Olkiluoto in 1999. After STUK’s favourable safety appraisal, the proposed host municipality informed the Government of its approval of the application and the Government made the requested decision in late 2000. Finally, Parliament almost unanimously (159 to 3 votes) endorsed the DiP half a year later.

The disposal concept is based on cooling of spent fuel bundles for 30-40 years, after which they are encapsulated in iron-copper canisters. The canisters will be deposited into a network of tunnels in crystalline bedrock at a depth of 400-700 metres and isolated from the rock by a layer of bentonite clay. After the operational period, all underground spaces will be backfilled and sealed and the surface buildings demolished. The disposal concept is illustrated in Figure 1.

Figure 1. **Illustration of the planned encapsulation and disposal facility at the Olkiluoto site**

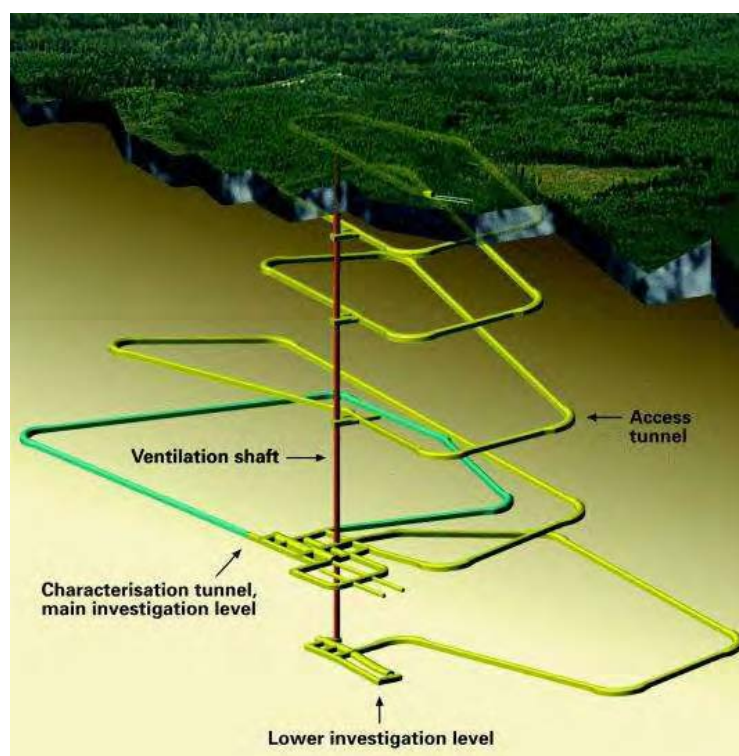




At the beginning of planning the disposal concept, it was thought that the crystalline rock would be an important release barrier. However, during the research programme it has become evident that it is not possible to prove that the rock has sufficient integrity. It has also been learned that certain radionuclides will adhere through chemical bonds to the crystalline rock, while others would be transported with groundwater if released from a container. In the current concept, the most important safety factor in preventing radioactive releases from a disposal facility is provision of reliable engineered release barriers – the container and other barriers installed inside or around it. The fuel itself keeps most of the radionuclides tightly in its ceramic structure and these nuclides would be released extremely slowly even if the integrity of the container were to be lost. In any case, the main objective is to keep the container intact as long as the spent fuel contains more radioactivity than the natural uranium which was the original source of the fuel. This time is around 250 000 years. The container is a 50 mm thick copper canister with a welded lid. This thick container is estimated to withstand corrosion for more than one million years if the chemical conditions around it are not significantly changed from the current situation. In order to protect the container from mechanical impacts and from direct exposure to groundwater flow, it will be surrounded by a layer of bentonite (special clay). The main purpose of the 400 m layer of crystalline rock above the canisters is to protect them from mechanical and chemical environmental impacts and from human intrusion.

The next licensing step, pursuant to the nuclear legislation, is the construction licence. According to the decision by the Ministry of Trade and Industry, the respective application should be submitted in 2012 at the latest. Currently, Posiva Oy is conducting an extensive research, development and technical design programme aiming at achieving preparedness for the submission of the construction licence application. The programme includes site confirmation studies, technical design of the facilities and the engineered barrier system, as well as development of safety assessment tools and databases. An underground rock characterisation facility (URCF, see Figure. 2), the construction of which was started in mid-2004, plays an important role in Posiva's programme.

Figure 2. Design of the Underground Rock Characterisation Facility (URCF)



The construction of the URCF already means *de facto* construction of the disposal facility because the access tunnel, the shafts and other underground parts will be used during disposal operations. However, a construction permit is needed before starting construction of the encapsulation facility and the first disposal tunnels. The operating licence process is scheduled to take place around 2020.

The spent fuel disposal programme is subject to regulatory oversight by the Ministry of Trade and Industry (administration, management of nuclear waste fund) and STUK (safety regulations, safety assessment and inspections). The main regulatory tools in the current preparatory phase have been safety regulations and triennial reviews of the implementer's research, development and technical design programme. Construction and operation of the URCF, which is envisaged to constitute a part of the disposal facility, is particularly subject to STUK's inspection and review activities. The implementation of the spent fuel disposal facility and related regulatory control is detailed in Table 1.

Table 1. **Implementation and regulatory oversight of the spent fuel disposal programme**

Period	Implementation	Regulatory oversight
1983-1999	<ul style="list-style-type: none"> <li>• Conceptual design, research and development.</li> <li>• Site selection process: 100 &gt; 6 &gt; 4</li> <li>• Detailed site investigations.</li> </ul>	<ul style="list-style-type: none"> <li>• Government's policy of 1983.</li> <li>• STUK's safety reviews of 1987, 1994 and 1997.</li> </ul>
1997-2001	<ul style="list-style-type: none"> <li>• EIA programme and report.</li> <li>• DiP application for a disposal facility at Olkiluoto.</li> </ul>	<ul style="list-style-type: none"> <li>• Safety regulations 1997.</li> <li>• EIA hearings and judgement.</li> <li>• STUK's preliminary safety appraisal as part of the DiP process.</li> </ul>
2000-2012	<ul style="list-style-type: none"> <li>• Confirming site investigations, including URCF ("Onkalo").</li> <li>• Research and technical development, start detailed design.</li> </ul>	<ul style="list-style-type: none"> <li>• Updated safety regulations 2008.</li> <li>• Oversight of site investigations and construction of "Onkalo".</li> <li>• Review of the status and plans for research and technical development in three year periods.</li> </ul>
2012-2020	<ul style="list-style-type: none"> <li>• Construction licence application.</li> <li>• Construction of the facilities.</li> </ul>	<ul style="list-style-type: none"> <li>• Review of licence application.</li> <li>• Oversight of construction.</li> </ul>
2019-	<ul style="list-style-type: none"> <li>• Operating licence application.</li> <li>• Operation of the facilities.</li> </ul>	<ul style="list-style-type: none"> <li>• Review of licence application.</li> <li>• Oversight of operation.</li> </ul>

### **General safety regulations for disposal of nuclear waste**

The first Government decision on safety regulations for low- and medium-level nuclear waste was issued in 1991 and for spent nuclear fuel in 1997.

A new draft of a Government Decree combining the two previous decisions and making the requirements more accurate has been prepared this year and circulated for comments by all Finnish organisations that are competent in the field. It is expected to be issued during the first half of 2008.

This section discusses the contents of the new draft for mandatory safety regulations.

The general goals and principles of radioactive waste disposal are the following:

- High-level protection of workers, the public and the environment.
- No future detriments exceeding currently acceptable levels.

- No reliance on long-term surveillance.
- Implementation of disposal with due regard to safety and with appropriate timing of the various steps of the disposal process:
  - Decrease of waste activity through interim storage.
  - Utilisation of high technology and scientific knowledge.
  - Need for ensuring long-term safety with research and performance monitoring.
  - No unjustified delays in the implementation process.
- Ensuring the operational and long-term safety by means of:
  - Use of proven or otherwise carefully examined, high quality technology.
  - Adoption of an appropriate quality management system.
  - Maintenance of an advanced safety culture.
- Continuous safety improvement considering:
  - Operating experience.
  - Results of safety research.
  - Progress in science and technology.

The radiation protection criteria are specified separately for different time periods, namely:

- The operational period.
- The reasonably predictable future.
- The era of extreme climate changes.
- The distant future.

A useful way to put the time scale in perspective is to compare the radioactivity of the spent fuel with the radioactivity of the uranium that was needed for manufacturing of the respective fuel. The time to reach a one-to-one ratio is 250 000 years. On de-fuelling, the spent fuel radioactivity on this scale is 4 million, after 40 years (start of disposal) 7 000, after 500 years 100 and after 10 000 years 15.

For the operational period, dose-based radiation protection criteria are used as follows:

- Practically no releases from normal operation.
- 0.1 mSv/a for anticipated transients.
- 1 mSv/a for postulated accidents with probability  $> 10^{-3}/a$ .
- 5 mSv/a for postulated accidents with probability  $< 10^{-3}/a$ .

The reasonably predictable future starts from closure of the repository and lasts for several thousands of years. It is expected that, during this time, a boreal or temperate climate will prevail. However, considerable environmental changes will occur due to *e.g.* land uplift. Geological conditions are stable or change predictably (*e.g.* groundwater chemistry). Radiation protection criteria are based on doses (or dose expectancies) to members of hypothetical critical groups due to early failure scenarios. These are as follows:

- Highest individual doses from expected evolution scenarios  $< 0.1$  mSv/a.
- Insignificant average doses to larger population groups.
- Whenever practicable, the consequences and expectancies of radiation impacts from unlikely disruptive events shall be assessed in relation to the constraints.
- Critical group: a self-sustaining community in the environs of the disposal site.
- Potential impacts on species of fauna and flora shall also be examined.

The era of extreme climate change starts after several thousands of years and continues for about 200 000 years. The transition to glacial or permafrost climate type takes place 5 000-20 000 years from now. The range of potential environmental conditions will be very wide and dose assessments would be meaningless. Major geological changes (groundwater flow and chemistry, rock movements) will occur, but their ranges can be estimated. Radiation protection criteria are based on release rates of radionuclides from the geosphere (geo-bio flux constraints). Maximum impacts must be comparable to those arising from natural radionuclides and large-scale impacts must be insignificant. Release rate constraints are to be given in STUK's guide and are:

- 0.03 GBq/a for Ra, Th, Pa, Pu, Am and Cm isotopes.
- 0.1 GBq/a for Se-79, I-129 and Np-237.
- 0.3 GBq/a for C-14, Cl-36, Cs-135 and for U isotopes.
- 1 GBq/a for Nb-94 and Sn-126.
- 3 GBq/a for Tc-99.
- 10 GBq/a for Zr-93.
- 30 GBq/a for Ni-59.
- 100 GBq/a for Pd-107 and Sm-151.

Beyond about 200 000 years, the potential radiotoxicity of spent fuel becomes less than that in the natural uranium from which the fuel was fabricated. The hazard posed by the repository is therefore comparable to that from a uranium ore deposit. No rigorous quantitative safety assessments are required, but demonstration of safety can be based on simplified bounding analyses, comparisons with natural analogues and observations of the geological history of the site.

In addition to the radiation protection criteria, specific requirements are placed on the performance of the barriers. A system of multiple barriers is required so that long-term safety is not jeopardised by a deficiency in one of the barriers or by a predictable geological change.

Engineered barriers will provide almost complete containment for a time period of:

- Several hundreds of years for short-lived waste (*e.g.* operational L/ILW from NPPs and most NPP dismantling waste).
- Several thousands of years for long-lived waste (*e.g.* spent nuclear fuel or activated metal waste from dismantling of NPPs).

Short-lived nuclear waste is defined as waste with activity concentrations after a time period of 500 years of less than:

- 100 MBq per kg in each disposal package.
- 10 MBq per kg waste in each disposal room.

Long-lived nuclear waste is defined as waste exceeding these activity concentrations after a time period of 500 years.

The host rock has to be favourable for the isolation of radionuclides from the biosphere. This requires blocks of bedrock with adequate size and intactness for the construction of the waste emplacement rooms. The host rock must not have unsuitable features such as proximity to natural resources, abnormally high rock stresses, anomalous tectonic or seismic activity, or adverse chemical features of groundwater.

During implementation of disposal, the host rock will be characterised by means of surface-based and deep investigations. The characterisation is needed both for the design of the emplacement rooms and for obtaining data required for the safety assessment.

The depth of the disposal facility will be selected with due regard to local geological conditions. The aim is to mitigate the impacts of the above-ground events, actions and environmental changes on long-term safety and to render inadvertent human intrusion to the repository difficult.

The excavation, other construction and closure of the underground facility will be implemented in the best manner possible with regard to retaining the characteristics of the host rock that are important to long-term safety and preventing adverse effects on the operational safety or the integrity of the disposed waste packages.

### **Demonstration of the long-term safety of the nuclear waste disposal concept**

The long-term safety case must address both expected evolutions and unlikely disruptive events. It has to include a quantitative assessment as well as complementary considerations whenever such quantitative analyses are not feasible or are too uncertain.

The safety case must be based on high quality experimental knowledge and expert judgement, and use models and data which are site-specific and validated as far as practicable. It must also adhere to the principle of conservatism and discuss the implications of uncertainties.

The safety case must be included in the PSAR, FSAR and closure plan and it must be updated every 15 years during operation.

### **Elements of successful implementation of nuclear waste and spent fuel disposal**

The basic preconditions for successful implementation of nuclear waste disposal are political commitment to resolving the issue, clear liabilities and a well defined regulatory framework.

The scientific and technological programme for implementation needs to be of high quality and transparent.

The siting process must progress in a stepwise manner and be open and defensible in each step.

Local and national trust needs to be achieved with the support of competent regulatory staff who are available to respond to the questions and concerns of the public and demonstrate their honesty and service-minded attitude in practical encounters with the public.

Finally, the importance of socio-economic benefits to the local public must not be underestimated.

### **Prospects for the future**

The Finnish spent nuclear fuel management programme is currently firmly based on the once-through option. Spent fuel is stored in on-site pool-type facilities and enlargement of these is foreseen in early 2010s to cover the required capacity prior to the commencement of disposal operations around 2020. Disposal operations will continue into the next century, although the first compartments of the repository would be closed and sealed in the middle of this century.

However, international developments in the fuel cycle area, such as partitioning and transmutation technology, are followed and regularly assessed in Finland. The long storage period before permanent disposal leaves the various spent fuel management options open. If the reprocessing alternative becomes competitive in price or desirable for other reasons, such as the need for the contained plutonium and uranium as an energy source in a sustainable fuel cycle, it will be possible to switch the strategy and to use the constructed repository for disposal of high-level radioactive waste only. The disposal concept is retrievable and recovery of the spent fuel bundles is thus feasible even after disposal.

## **Radioactive Waste Disposal in Hungary from the Regulator's Viewpoint: Ensuring Protection and Creating Trust**

**József Rónaky**

Director General, Hungarian Atomic Energy Authority, Hungary

### **Introduction**

Nuclear power provides a substantial portion of the total electricity produced in Hungary. The source of nuclear power is the Paks NPP's four VVER-440 nuclear reactors. As yet, there is no decision on the back-end of the fuel cycle and the spent fuel assemblies are stored for 50 years in a dry storage facility in the neighbourhood of the power plant. Due to this facility, we have gained sufficient time to elaborate a detailed HLW strategy. Nevertheless, one thing is for sure: whatever decision is made on the closure of the fuel cycle in the future, Hungary will still face the problem of disposal of residual high-level waste from reprocessing, which requires the same deep geological disposal solution as the direct disposal of unprocessed spent fuel assemblies. However, the most urgent problem in the field of radioactive waste management in Hungary today is not the complex and as yet unsolved issue of HLW disposal, but a completely different non-technical one: How to create trust for a new repository which accommodates short-lived L/ILW of NPP origin at a few hundred metres depth in granite? In the present paper, the lessons we have had to learn in the past two decades are summarised.

In the 1960s, the general concept laid down by the Russian designers for the management of waste from a VVER-type NPP was to store on-site and to postpone the decision on the detailed manner of conditioning and disposal until decommissioning. This strategy was considered advantageous because the waste from operation and that from dismantling could be handled together. However, during licensing of the first VVER units in Hungary in the late 1970s, the authorities turned down the above waste management strategy (taking more rigorous radiation protection considerations into account) and required an adequate solution for the problem. Accordingly, in 1978 a site selection process aiming at a near-surface repository suitable for final disposal of L/ILW from the nuclear power plant was launched. In 1983, the Hungarian Academy of Sciences was requested by the Government to assist the site selection process. After evaluating the results of investigations, the Academy recommended a further detailed study of the site at Ófalu, a South-Transdanubian village in Baranya County.

### **Ófalu**

After completing a research programme by 1987, the Paks NPP applied to the competent authority (Ministry of Health) for a construction licence as required by Act I of 1980 on atomic energy. Prerequisites for the licence were the approvals of other specific authorities, for example the regionally competent building authority was the Construction and Water Department of the Baranya County Council at that time.

The licensing procedure was based on a purely technical approach and public acceptability was completely ignored. Although the research activities and investigations were carried out in accordance with international practice of that time, the locals heatedly protested against the repository. Among the local communities, the general mood was opposition to any idea of a radioactive waste repository. The simple "not in our backyard" attitude was combined with a growing antipathy against the initiations of governments lacking honest communication with locals. They expressed their mistrust against the experts of the NPP and set up a so-called Independent Expert Commission. Following the failure of

reconciliation efforts between the Commission and the NPP, the regional building authority did not grant approval for construction. The rejection was based on one of the Expert Commission's objections on relative closeness to some temporary springs. This consideration was obviously outside the competence of a building authority.

Acting under pressure from the public, in June 1988 the competent authority of the Ministry of Health rejected the application for the construction licence on account of the negative standpoint of the Baranya County Council.

The Paks NPP appealed against the rejection. The Hungarian Academy of Sciences was invited again to look at the scientific questions that had arisen during the siting process. An ad hoc committee of the Academy found that the disposal facility would not be a danger to the environment; however, the decision should be made not only on the basis of scientific and economic investigations but also in agreement with the communities concerned. Finally, in January 1990, the Minister of Health dismissed the appeal of the Paks NPP against the refusal of the construction licence. The three year long licensing procedure thus came to an end.

### **Lessons learned from the Ófalu process and the restart of site selection**

The Act on atomic energy that was in force in the 1980s addressed only general principles regarding radioactive waste management. In the meantime, it has been shown that more elaborate regulations would have been necessary. The Act covered mainly NPP construction and operation issues and the problems connected with decommissioning and final disposal of all types of wastes remained to be resolved. A clear division of responsibilities among the government, the NPP operator and national authorities was also missing. It cannot be overemphasised that the involvement of the public was completely ignored at the early stage of the licensing procedure and this finally led to massive opposition to the repository.

In 1992, the Hungarian Atomic Energy Commission declared that the safe and socially acceptable disposal of radioactive waste required the coordination of complex scientific, economic, technological, social, legal, financial and international activities. To achieve this goal, an interdepartmental project was established in which all responsible ministries and competent organisations participated. Accordingly, a national programme was launched in 1993 aimed at siting for disposal of L/ILW from the Paks NPP. From the very beginning, honest cooperation with the local municipalities and informing the public were given high priority.

In 1996, based on geological investigations and safety and economic studies, the decision was made to carry out further explorations for geological disposal in granite in the vicinity of a South-Transdanubian village: Bábaapáti (Tolna County).

### **New regulatory framework**

In the 1990s, in line with worldwide developments, important new regulations were issued. The Act LIII of 1995 on general rules for the protection of the environment and its executive orders regulated in detail the involvement of the public and interested non-governmental organisations in the environmental licensing process, based on an Environmental Impact Study.

On 1 June 1997, the Act CXVI of 1996 on atomic energy entered into force in Hungary, expressing the national policy in the application of atomic energy. It regulates, among other things, the basic aspects of radioactive waste management and authorises the Government and the competent ministers to issue executive orders specifying the most important requirements in this field.



As of 1 January 1998, the Act on atomic energy established the Central Nuclear Financial Fund based on payments by parties using nuclear energy. The goal of this Fund is to finance the costs involved in the disposal of radioactive waste, interim storage and final disposal of spent fuel, as well as the decommissioning (dismantling) of nuclear facilities. The member of the Government supervising the Hungarian Atomic Energy Authority (HAEA) is responsible for the disposition of the Fund and the HAEA is responsible for its management.

The Act declared that radioactive waste management is of national interest and required that a special body, the Public Agency for Radioactive Waste Management (PURAM), should be established for the management of radioactive waste and spent fuel, and for the decommissioning of nuclear facilities. The Act authorised the licensee (PURAM) to financially support information associations of the local municipalities.

The importance of radioactive waste management is also reflected in the requirement that a preliminary approval in principle by Parliament is needed to launch the preparatory work for constructing any radioactive waste repository. The executive orders of the Act regulate the geological and mining requirements for the siting and planning of radioactive waste disposal facilities, the issues of discharges and radiation protection, as well as the safety and licensing requirements for interim storage and final disposal of radioactive wastes.

### **The B́ataaṕati repository**

The site investigations in B́ataaṕati continued within the new legal and organisational framework. In 2003, the final report of this exploratory work, approved by the competent authority, stated that the site is suitable for a L/ILW repository. The repository will be at a depth of about 250 m below the surface in granite rock, accessible through inclined shafts. Now, two inclined shafts, each with a cross-section of 21 m<sup>2</sup>, are being excavated with a planned length of 1700 m.

The research work has been supported by the population of B́ataaṕati and its vicinity from the beginning. 75 per cent of the inhabitants of B́ataaṕati took part in a local referendum in July 2005 and voted to support the construction of a repository with a majority of more than 90 per cent. This decision was followed by supporting resolutions of the local governments in the surrounding settlements.

Also, approval in principle of Parliament became necessary. The approval given by Parliament on 21 November 2005 acknowledged that the construction of the facility serves the interests of the whole society.

For licensing purposes, further geological investigations and preparatory activities, as well as safety assessments, are required. The Environmental Impact Study has already been prepared and accepted by the relevant authority. However, a non-governmental organisation appealed against the acceptance so this crucial part of the licensing procedure has not yet been completed. The application for a construction licence is being prepared and, depending on the outcome of the environmental licensing, it will be filed with the competent authority under the Ministry of Health.

According to the schedule, the first four underground disposal chambers will be ready by 2009. Certain parts of the surface facilities will start operation in 2008, allowing interim storage of about 3 000 drums containing waste from the nuclear power plant that is running out of storage capacity.

### **Conclusions**

After the failure of the site selection process in Ófalu, favourable changes took place that led to the success in B́ataaṕati. Key elements of these changes are summarised below.

A new legal framework has been laid down. The Act on protection of the environment and its executive orders regulate in detail the involvement of the public in the licensing process. The licensing is based on a comprehensive Environmental Impact Study which has to be presented at public hearings. In the decision making, the opinions of stakeholders (interested individuals and other organisations) also have to be taken into consideration.

The new Act on atomic energy established a clear distribution of responsibilities and tasks among the authorities and other participants in the field of radioactive waste management. A special body, the Public Agency for Radioactive Waste Management, was established with sole responsibility for radioactive waste management in Hungary. To finance the cost of radioactive waste management (spent fuel storage and disposal, waste disposal and NPP decommissioning), a Fund (Central Nuclear Financial Fund) was set up. Associations of host and neighbouring municipalities were organised to ensure that people receive direct information from the licensee and – in a certain sense – are able to control nuclear facilities and siting activities in their surroundings. It is also a very important regulation in the Act on atomic energy that the licensee is entitled to provide financial support to these associations.

Besides these changes, the real breakthrough is that Hungarian society has realised how important it is to solve the problem of radioactive waste disposal as a prerequisite for safe nuclear energy production, which is a problem not only of the NPP but of the whole country. This consensus manifested itself in 2005 when the Hungarian Parliament granted its approval in principle to the Bataapáti project.

## **International Approach to Harmonising the Requirements and Processes for a Geological Repository**

**André-Claude Lacoste**

President, Nuclear Safety Authority (ASN), France

### **Introduction**

A number of countries are developing, or considering the development of, geological disposal facilities for radioactive waste. Achieving consistency among countries on practical and technical approaches to providing a high level of safety for such facilities is a foreseeable and beneficial objective. Important steps have already been taken successfully by organisations such as the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA) in developing internationally agreed standards, guidance, recommendations and collective opinions. Within the European Union, the Western European Nuclear Regulators' Association (WENRA) is developing reference safety levels for radioactive waste and spent fuel storage and for decommissioning. Several European regulators decided in 2005 to initiate a process for sharing experiences and opinions regarding regulatory expectations for the safety review of a geological disposal project.

### **The IAEA effort**

The IAEA organises discussion groups at different levels with a view to preparing documents known as "Safety Standards", describing safety principles and practices which can then be used by Member States as a basis for national regulations. Since the beginning of 1996, this activity has been regulated by the CSS (Commission on Safety Standards), comprising senior representatives of the regulatory authorities of twenty Member States, tasked with proposing standards to the Director General of the Agency.

These "Safety Standards", approved by the CSS and published under the auspices of the Director General of the IAEA, comprise three levels of documents: Safety Fundamentals, Safety Requirements and Safety Guides. In 2006, the CSS approved a single document presenting the fundamental principles for four aspects of safety: installation safety, radiation protection, safe management of waste and safe transport. This document was adopted by the Council of Governors in September and subsequently published. It represents the fruit of around ten years of work and will improve the consistency and transparency of the system.

Another important document published in 2006 after approval by the CSS is the WS-R-4 Safety Requirements document on geological disposal. The purpose of the document is to set down protection objectives and criteria for geological disposal and to establish the requirements that must be met in order to ensure the safety of this disposal option, consistent with the established principles for safety for radioactive waste management.

The intention of the IAEA is now to develop new requirements for disposal and to develop guidance for each type of radioactive waste disposal, i.e. near-surface disposal, intermediate-depth disposal and geological disposal. The draft safety guide on geological disposal has been sent to Member States for comments and a new version will be presented to the next session of the Waste Safety Standards Committee (WASSC). Another safety guide is currently being developed on the safety assessment of geological disposal. Those documents should improve the level of harmonisation of international regulations on the safety of geological disposal.

## **The WENRA effort**

The Western European Nuclear Regulators' Association (WENRA) was created in 1999. It originally consisted of the heads of the nuclear safety authorities of the member countries of the European Union, plus Switzerland, and initially provided the expertise for reviewing the safety of the reactors in eastern European countries applying for membership of the European Union. The authorities of these eastern European countries have since joined WENRA. One of the key WENRA missions is to develop a joint approach to nuclear safety and regulation. WENRA therefore implemented a procedure for drafting reference safety levels for harmonising nuclear safety practices.

Working groups were set up in 2002 in order to draft these reference levels. One of them, the WGWD (Working Group on Waste and Decommissioning), was more specifically tasked with defining reference levels for the safe interim storage of radioactive waste and spent fuel and nuclear installation decommissioning operations.

The reference levels for the interim storage of radioactive waste and spent fuel and for the decommissioning of nuclear installations were published on the websites of the WENRA member authorities at the beginning of 2006, in order to collect the opinions of stakeholders before they are enshrined in national regulations by 2010. The comments received led the WGWD to revise these levels in order to deal only with aspects which are more specific to the topic under consideration (interim storage and decommissioning), thus ensuring that a graduated approach was used in relation to the reference levels drafted by WENRA for reactors.

With regard to the reference levels for interim storage of radioactive waste and spent fuel, the main recommendations concern the need to identify the owner of the waste or fuel, to ensure that storage is reversible and to monitor the waste or fuel so that it can be recovered if damage is confirmed. Passive safety protection measures, in other words requiring no human intervention, are also preferred.

The reference levels concerning the safety of decommissioning operations require that the nuclear licensees produce decommissioning strategies for their sites and prepare decommissioning plans, that the more important decommissioning phases be submitted to the safety authority for review and that decommissioning be designed into the nuclear installation in order to facilitate all operations as and when the time comes.

The possibility to address safety issues raised by radioactive waste disposal was examined by WENRA, but some regulators of the Association were not directly in charge of regulating the safety of radioactive waste disposal.

## **The European Pilot Study**

In parallel, France and Belgium have cooperated to develop common ideas on the safety approach to geological disposal and have reached joint positions that were presented to European regulatory bodies and international organisations. The French-Belgian initiative generated valuable momentum and it was considered that other interested countries within the European Union could be brought in to develop common views for the region. A pilot study was implemented to share experience and opinions on the expectations of the regulatory bodies regarding the content of a safety case for geological disposal of radioactive waste at the different steps in a project for developing such a facility. The pilot study was carried out from 2005 to 2007 by a group of representatives from regulatory bodies and technical support organisations from Belgium (FANC, AVN), the UK (EA), France (ASN, IRSN), Germany (GRS), Spain (CSN), Sweden (SSI) and Switzerland (HSK), as well as representatives of international organisations (IAEA, EC). The pilot study was undertaken within the framework of terms of reference agreed upon by members of the group.

The group held meetings with a frequency of every 2 to 3 months and worked, on the one hand, on the regulatory approach and the integration of safety elements in the safety case and, on the other hand, on a more specific topic concerning the management of uncertainties. After nearly two years, the European pilot group has produced 2 reports. The first, *The regulatory review of the safety case for geological disposal of radioactive waste*, addresses the main issues raised by the assessment of a staged safety case for a geological disposal facility; the second, *Case study: Uncertainties and their management*, addresses the treatment of uncertainties in such a project. The European Pilot Study pointed out the need to identify the elements of the safety assessment to be addressed in the safety case by the implementer of a geological disposal facility. These elements are those related to siting and design of the facility, those associated with radiological impact assessment and those associated with the management systems. The safety case should present the outcome of the assessment of these individual elements, their integration and an integrated assessment of the overall disposal system. The manner and the extent to which these different elements are assessed at any one step in the process of developing the facility will vary according to the step in question. Key steps of interest are conceptualisation, siting, design, construction, operation and closure. Within the pilot study, the first three steps were addressed in greater detail.

At the outset of a project, it is necessary to establish an overall safety strategy that addresses the design concept to be adopted and the approach to safety demonstration. The document developed has set out a general framework for demonstrating the safety of geological disposal, recognising the evolution of safety arguments, supporting assessments and other evidence that will be developed over the course of the project, based on the applicable requirements of the IAEA WS-R-4 document.

Uncertainties concerning the safety of repositories are unavoidable due to the complexity of the phenomena involved and the timescales under consideration. The management of such uncertainties is essential when developing a repository system and assessing its safety.

The report addresses three main topics: the safety strategy, the assessment strategy and issues of compliance. The document developed by the European Pilot Group has established a framework for demonstrating the safety of geological disposal, recognising that the safety arguments and supporting assessments and other evidence will evolve and mature with the project. Although regulatory frameworks differ considerably between countries, the European Pilot Group recognised that regulatory practice differs to a much lesser extent. The manner in which regulatory expectations have been addressed within the framework remains largely general in nature, but represents an emerging consensus. With further work, this could be expanded to become more detailed and precise. This work needs to be carried on within the same informal framework. European regulators may join the group on a voluntary basis.

## **Conclusion**

At an international level, there is a significant amount of documentation on the issue of the safety of geological disposal. The efforts of the NEA and the IAEA should improve the level of understanding of particular issues raised by disposal facilities that have to remain safe for tens of thousands of years. Those organisations provide forums where regulators and implementers can discuss how to demonstrate the safety of radioactive waste disposal. Even if the member countries of these organisations have different systems of regulations on nuclear safety issues or different strategies for the management of radioactive waste and spent fuel, there is a global need for the regulators to agree on the main requirements that should be integrated into the regulations on radioactive waste management. In Europe, WENRA has begun to harmonise reference safety levels for the storage of radioactive waste. The possibility to extend the harmonisation to geological disposal safety requirements has been considered through the European Pilot Study initiative.