Global Perspectives on High-Level Waste Management

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The geological disposal concept

Disposal of toxic wastes produced by industrialised societies is an increasingly challenging global problem. The goal must be to find solutions that are safe, protect the environment, are affordable and are acceptable to the public. For radioactive wastes, the acceptance challenges are even greater than for other toxic substances, because of the well known "dread factor" associated with radiation and because of the highly polarised political and public views on nuclear power technology, which produces most radioactive wastes. There are, however, some largely unacknowledged advantages when dealing with radioactive wastes. They are almost always produced under confined and controlled conditions, the volumes are very small compared with many other wastes and radioactive decay with time implies that isolation of these wastes for a sufficiently long period may be, in practice, a permanent solution to the problem. For long lived radioactive wastes, this isolation is usually planned in secure engineered interim storage facilities and ultimately in deep geological repositories.

For at least 25 years after the original 1950's publications on the concept of geological disposal, the validity of this approach was not questioned. It was formally adopted as a final goal, through policy or legal decisions, in many countries, including Belgium, Canada, Finland, France, Japan, Russia, South Korea, Spain, Sweden Switzerland, and the USA. Several of these countries initiated active scientific and technical programmes aiming at implementing disposal, usually some 20 years or so into the future.

However, virtually every geological waste disposal programme in the world ran into difficulties in keeping to originally proposed schedules. For example, in the US programme, in 1982, a target date for repository operation of 1998 was set. Currently the target for a US repository at Yucca Mountain is 2012 and this goal is unlikely to be met, given all outstanding technical, licensing and legal issues. Other programmes have also been compelled to move target dates back. Through to the year 2000, the only active programme that met its original deadlines, even for selection of a preferred site, was Finland.

Slippages in deadlines, however, are common in large projects; disposal programmes are not unusual in this respect. Less common are decisions of the type taken in some countries – namely to indefinitely postpone implementation of geological repositories. This has happened several times, in each case due to public opposition leading to governmental decisions to halt the siting process. Examples are the Netherlands, Spain, the UK and the Czech Republic.

In a few countries, there has been a still more radical political reaction to problems encountered by geological disposal programmes. This began in France, where intense opposition to siting efforts in crystalline rock areas, together with growing opposition to disposal per se, led in 1990 to a new law in which the geological disposal option was treated as one of three lines to be followed. The other two, transmutation and long-term storage, were to be studied with equal intensity at least up to a decision date set for 2006.

Backing off from the choice of geological disposal as the preferred national strategy has since taken place in two further countries, namely the UK and Canada. The former country suffered the catastrophic loss of the proposed Sellafield site as a result of a public hearing that severely criticised the scientific, engineering and societal aspects of work by UK Nirex. The UK government decision was to re-open all alternatives and to have a very wide public debate before choosing a preferred future course. In Canada, the Government also decided to re-open discussion on all conceivable long-term spent fuel management options following the review by the Seaborn Committee of the major disposal study submitted by AECL. In the Canadian case, the science and technology was not faulted; the proposed repository concept was judged technically capable of providing safety. However, it was also judged that the public confidence in the safety was insufficient to allow an implementer to proceed to specific repository siting. The subsequently founded Canadian waste agency, NWMO, has recently advocated moving again ahead towards geological disposal – but in an adaptive staged approach.

Current trends in disposal projects

What is the actual situation around the world today? The present position is that technologies for implementing deep geological disposal have been developed and extensively tested in a number of countries, although fully implemented in only very few cases. These technologies are based on different conceptual designs for a deep repository, including the choice of the engineered barriers that enclose the used nuclear fuel and also the geological medium in which the repository will be sited. In all of these different programmes the safety of the deep geological system - as assessed by the range of methodologies developed for this purpose - is invariably shown to be very high. Nevertheless, there is extensive scepticism in some circles concerning the ability of scientists to actually model how the system will evolve for

tens of thousands or hundreds of thousands of years. The counter-arguments of the repository implementers have not convinced all stakeholders in various countries, and accordingly the progress of deep geological disposal projects has been different in countries around the world.

This rather sobering look at the status of geological repositories in some countries contrast strongly with the advances made recently in some other parts of the world. In the USA, congress decided that a licensing application should be prepared for the Yucca Mountain Project in Nevada. Even if the ambitious deadline currently aimed at by the USDOE is not maintained, a deep repository for used nuclear fuel is likely to be constructed and operated in the United States in the foreseeable future. In the Scandinavian countries, Finland and Sweden, the deep repository programmes are also very advanced and steering towards a definitive date for implementation. More influential, perhaps, than the technical developments that have been initiated in these countries, are the societal processes that have been invoked to try and ensure that the repository has a sufficient level of acceptance. In most other countries of the world, the combined technical and societal approaches employed in the Scandinavian countries are looked upon as role models for how things might be arranged also in other programmes. In Asia, the Japanese HLW disposal programme has moved rapidly to become a leading example, siting work is being undertaken also in Russia and in China.

In the European Union, a recent directive attempted to compel European Union member states to set specific deadlines for siting repositories. This thrust confirms that, for the European Union, deep geological disposal is indeed the preferred waste management strategy for used nuclear fuel and high-level wastes. Support for the concept of deep disposal is apparent also in many of the small Central European countries that have become EU member states. For these small countries, however, and for numerous other small countries around the globe, an important difficulty standing in the way of implementing the deep disposal strategy is that deep geological repositories, if properly designed, sited, operated and closed, are simply too expensive. Nevertheless, these nations will also need a safe and secure long-term waste management option for these wastes. This is a prime reason for the increasing interest in the concept of shared deep geological repositories.

Does every country need a national geological repository?

Achieving acceptable levels of long-term safety requires suitable geological environments to be available. However, repository designs are flexible, and requirements on the natural barriers can be matched to the degree of sophistication of the engineered barriers. This can be seen in the range of designs that is currently being developed by the advanced national programmes. Thus, most countries should be able to find suitable disposal sites. However, even where a national repository is technically feasible, it may be ruled out by economics. A deep geological facility for long-lived radioactive wastes can cost several billion US dollars, no matter how small the volume of wastes to be disposed, and it is inconceivable that each country with such wastes will be able to provide adequate resources. Some countries have only a single reactor; some have no power reactors but still produce long-lived wastes from medicine research and industry. For such countries, shared geological repositories are essential. For other countries, complex geology, intense land use, or economic optimisation will justify pursuing international options, even if national disposal could be realized. Various small countries (e.g., Switzerland, Belgium, Hungary and Taiwan) have also advocated a ‘dual track’ approach in which international options are kept open while a national option is also being considered.

Shared multinational disposal facilities

Development of regional, multinational repositories could be an alternative or complement to national geological disposal programmes – in particular for countries with small volumes of wastes, a scarcity of available space, or complex geology. Although ethical considerations and international rulings correctly emphasise that each country must bear the responsibility for ensuring that its radioactive wastes are safety managed, this does not necessarily mean that each must have a national disposal facility. Today, however, there is still some sensitivity towards potential negative public reactions and several countries, e.g. the UK, France, Sweden and Finland. Nevertheless, there is continuing support in numerous countries for the concept of shared repositories and Russia, supported by the IAEA, has even expressed direct interest in hosting an international repository.

In recent years there has been an active debate on the pros and cons of repositories shared by several countries. The issues addressed include the following: safety, security, reducing negative environmental impacts, economic issues, public acceptability, ethical issues, political issues. The debates have shown that there are potential benefits of international solutions for both repository host countries and for user countries. These can be summarised as follows:

Multinational repositories can provide a valuable service to countries with:

- small areas, complex geological environments
- limited nuclear power
- no nuclear power - but long-lived wastes
- limited financial means
- interest in economic optimisation

- commitment to non-proliferation

Multinational repositories can be a valuable asset to countries with:

- suitable geological and environmental conditions
- remote, low population areas
- a stable political system
- the trust of the international community
- ability to provide high-tech infrastructure
- interest in economic development
- interest in expanding their global influence

Although the concept has been the subject of much study in recent years, implementation of common repositories used by various countries has not yet proven feasible on a significant scale. There are two possibilities that have been studied most. The first is "partnership scenarios" where a number of smaller nations agree to develop in one or more of their territories facilities available to all. The other case involves an "add-on scenario", where a large host country, with significant national wastes to be managed, agrees to accept also wastes from other countries. This service can be offered for financial reasons (as Russia has proposed) or for security reasons (which have led to both Russia and the USA accepting used research reactor fuel from abroad).

Increased importance on security and non-proliferation

Recently, the potential non-proliferation and security advantages have often been stressed, in particular following the series of terrorist attacks from 2001 onwards. Repeated statements by the Director General of the IAEA have pointed out the need to control the most sensitive parts of the fuel cycle. It is important to note that these include not only enrichment of fissile uranium and reprocessing, to separate plutonium, but also long term storage and disposal of SNF/HLW. This point is made clear in the February 2005 report published by the Multinational Approaches (MNA) Expert Group that the DG set up in mid-2004. The MNA report addresses the security and non-proliferation issues in a manner directly applicable all aspects of the nuclear fuel cycle, and suggests five specific approaches for multinational initiatives. The MNA Group recommends early implementation of shared storage facilities, with the essential addition of an agreed further step involving disposal in multilateral repositories – either in the countries storing the waste or in a limited number of other volunteering host nations.

What progress is being made?

In the past few years, there have been significant developments towards multinational repositories in several respects. Some key points are listed briefly below.

IAEA support:

- A series of public statements by the Director General emphasizing the need for multinational approaches
- Publication of a technical document on multinational disposal and one on regional storage
- Establishment of Multinational Approaches Expert Group mentioned above
- Sponsorship of the meetings mentioned below on international storage and disposal in Russia

European Commission support:

- Inclusion of regional repository concepts in draft EC Waste Directive
- Support of the SAPIERR project mentioned below

Further international developments:

- Support by US workers at MIT working a project on "The Future of Nuclear Power"
- Financing by the independent Russel Foundation of US Academy of Sciences-Russian Academy of Science meeting on international repositories in Vienna
- The topic of multinational disposal is integrated into numerous international Conferences on waste management at the technical and also the legal level

The Arius Association:

- Increased membership
- Progress with SAPIERR project, described below
- Preparation of follow-on EC project

The SAPIERR project:

- Publication of interim report on European inventories and report on legal positions
- Preparation of report on future initiatives for European region repositories

- Preparation of open concluding seminar in Brussels in November 2005

Russian developments:

- Government efforts to establish legal basis for import
- Joint Russian Academy of Science – US National Academies Workshop held in Vienna in June 2005 as follow-on from Moscow 2003 meeting
- Dedicated conference sponsored by the Russian Ministry of Atomic Energy and the IAEA in Moscow in July 2005

The Asian context

The problems of implementing geological repositories are greatest in countries with dense populations, complex geology and/or limited financial resources. Some or all of these conditions apply to various countries in Asia – especially when one considers that even non-nuclear-power countries require access to safe storage and disposal for radioactive wastes from medicine, industry and research. Moreover, Asia is the region of the world in which most growth of nuclear power is expected. This is an objective not just in the large countries like China, but also in Indonesia, Vietnam etc. There are therefore sound reasons for exploring regional repository concepts in Asia, beginning on the lines illustrated by the European SAPIERR project. There is, however, no direct Asian equivalent of EURATOM, which has been the direct supporter of SAPIERR. Alternative arrangements must be made. In parallel with small Asian programmes looking for shared solutions, of course, the option of adding on to a large programme should also be developed further.

The most obvious host countries would be China and Russia, with their ambitious national plans for nuclear power and their very extensive territories, which certainly include highly suitable geological environments. In the highly sensitive field of radioactive waste disposal, however, no country will be able to export its wastes to another unless it can be assured that this will not lead to any reduction in safety or environmental standards. Both the large countries mentioned would need to demonstrate much increased levels of transparency and readiness to be subjected to external controls and scrutiny if they are to gain the necessary confidence of the international community.

There is a strong sustainability argument behind the drive to ensure that a geological disposal option is available to each country. Geological disposal is recognized as being the only sustainable solution to managing long-lived wastes, because it does not pass on problems to future generations who may have neither the resources nor the capability to handle them. This argument applies in any country and to any size of programme. However, it is perhaps an even more cogent argument for those countries, including several European and Asian countries with small waste inventories, where pressure on resources is already evident.

It is important for the global nuclear industry as a whole, and for the wider interests of environmental safety and nuclear security, that the radioactive waste management community demonstrates that the challenges of properly managing the wastes of 'small users' and countries with limited resources are being properly addressed (i.e., not being ignored while larger countries progress with strictly national programmes). Providing such solutions will also give the smaller programmes the confidence to make best use of their nuclear power facilities and to have greater flexibility in choosing future power generation options. In short, there should not be a two-tier system for disposal of hazardous wastes, and hence for the application of nuclear technologies. It is in everyone's best interests that equivalent technologies are available on equivalent time scales to all those countries that need them.