RECENT PROGRESS IN GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTES AND STRATEGIC ISSUES TO BE DEALT WITH IN THE PROCESS: EDRAM'S PERSPECTIVE

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Abstract

Various issues of deep geological disposal of radioactive waste, including alternatives to geological disposal, multinational approaches and costing / financing aspects are being discussed in the public and political sphere in a recurrent manner. EDRAM believes, as a group of senior executives from national agencies for implementing radioactive waste disposal in their respective countries, that drawing on international expertise, experience and collaboration is of great value and leads to better solutions for the safe implementation of radioactive waste disposal. Based on this belief EDRAM discusses strategic issues and technical and management matters, with a view to benchmarking and establishing best practices, develops a common understanding of waste management issues among implementers and positions thereof and coordinates actions in relation to international organisations. EDRAM continually exchanges information on these matters within the group and with international organizations and understands differences and commonalities among them deeply in order to be able to explain them to its stakeholders. In the paper summarized are some of major recent outputs from this discussion.

1. INTRODUCTION

Development of solutions for long-term management of spent nuclear fuel (SF) and high-level radioactive waste (HLW) should proceed irrespective of the future of nuclear power generation, although volumes of SF and HLW produced are small and they are safely stored on an interim basis and can be continued to be safely stored using current practices for many decades. Many countries have promoted research and development (R&D) programs on long-term management of them and concluded that their disposal in a deep-mined, geological repository (DGR), i. e. their geological disposal is technically safe and feasible.

After establishing a national strategy for the geological disposal and an agency that is responsible for the implementation of the strategy, some countries are now promoting the development of geological repository, having identified a potential site for such a repository. In Finland, construction license was granted for the first deep geological repository for SF [1], in Sweden license application was submitted [2] and in France [3], the application is to be submitted in this year. In Canada [4] and Switzerland [5], the siting process is ongoing, and its definition is advanced in Germany [6], Japan [7] and UK [8], though the progress in these countries take tortuous routes from time to time.

International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM) [9] is a non-profit association established in 1998 as a forum to promote exchange of knowledge, experience and information among senior executives from national agencies for implementing geological disposal of radioactive waste in their respective countries. Participation includes 12 organisations from Europe, North America and Japan.

EDRAM recognizes that the International Atomic Energy Agency (IAEA) has played important roles of not only verifying that States are honoring their obligations to use nuclear material and technology only for peaceful purposes, but also supporting member States by helping to build national confidence in radioactive waste management activities through the publication of technical information including safety-related standards and guidelines and promoting effective cooperation and experience sharing among member States in various meetings and through review missions.

From global perspective, however, various issues related to radioactive waste management are being discussed in the public and political sphere in a recurrent manner, in particular, alternatives to geological disposal, multinational approaches and costing / financing aspects. Furthermore, as we are living in

interdependent society, something happening in one country on waste management and, in particular, on deep geological disposal, has an immediate impact on other countries.

EDRAM believes, therefore, that we all need to continually exchange information on these matters between us and with international organizations so as to understand differences and commonalities among them deeply in order to be able to explain them to our stakeholders. There is a strong need for clear and coherent messages – in particular from international organisations – that will support, or in any case not adversely affect, advanced and future disposal projects.

Keeping this point in mind and believing that drawing on international expertise, experience and collaboration is of great value and leads to better solutions for the safe implementation of radioactive waste disposal, the EDRAM discusses strategic issues and technical and management matters, with a view to benchmarking and establishing best practices, develops a common understanding of waste management issues among implementers and positions thereof and coordinates actions in relation to international organisations.

In the following, summarized are some of major recent outputs from this discussion (NOTE: The current presentation is prepared based on the products of EDRAM, but the views presented here are those of the author and do not represent necessarily the views of the EDRAM).

2. EDRAM'S POSITIONS AND VIEWS

EDRAM recognizes that independently of future developments in nuclear energy, nuclear waste exists and must be managed in a safe and sustainable manner – now and in the very long term. For this management, strategies are needed from «cradle to grave », i.e. from waste generation to disposal – for all types of nuclear waste. A range of options regarding depth of disposal exists (from near-surface to deep geological disposal) and must be considered in the context of each national framework, based on the principle that:

— The burdens and responsibility for taking care of radioactive waste should not be passed on to future generations:
— Radioactive waste management is a societal, as well as a technical issue:
— There is a need for flexibility, as well as for open and ethical involvement of stakeholders in decision making.

EDRAM has developed position and views from time to time based on the discussion of strategic issues among implementers, where appropriate, for communicating its common view with international communities, whilst recognizing the value of open discussions with national governments and regulators. Included in the present paper are views on siting of DGR, community benefits, multilateral approaches, a proportionate approach to radioactive waste disposal, partitioning and transmutation on the long-term management of radioactive waste, and cost for geological repository projects.

2.1. Siting of DGR

Based on our learning and experiences from geological disposal siting processes, we have discovered that a proposed repository site must not only be technically suitable but also be socially acceptable. Social acceptability could not be secured by relying on the authority of science and the power of government. Achieving a sustainable level of social acceptability requires, at a minimum, a transparent process that respects the views of interested and affected parties, that appreciates the authenticity of those beliefs, and through which share with the public about the information on the assessment of geological suitability, decision making processes with right of withdrawal, community benefits and potential socio-economic and environmental effects. Successful projects now refer to forging partnerships with local communities, implying a more equitable and enduring relationship, to the benefit of safe implementation.

We also recognize that siting is complex and multi-dimensional; approaches will differ from country to country: implementers are pursuing win-win situations with communities that are considering acceptance of waste repository. Recognizing that siting processes are challenging, we must be prepared to adjust ourselves according to regional circumstances and variations in societal requirements.

2.2. Community benefits

EDRAM commissioned Anne Bergmans of University of Antwerp to prepare a report of which purpose was to establish an overview of community benefits that were made available for communities hosting radioactive waste facilities in EDRAM member states [10]. The report pointed out that:

— Where the siting of radioactive waste management disposal facilities is concerned, socioeconomic community benefits generally form a substantial part of facility siting efforts and good community relations in EDRAM member states.
— Although all implementers stress the impact of the facility on the local economy as a benefit in itself, in terms of additional employment, local procurement and potential spin-offs, there is growing recognition that communities willing to fulfil an essential service to the nation by hosting a final repository of radioactive waste are entitled to receive added-value measures to develop their social and economic wellbeing.
— These additional benefits come in various shapes but tend to fall under either one of the following five categories: (1) additional investments in local infrastructure, (2) additional local activity, (3) specific subsidies and grants, (4) offering support in the form of training and logistics, or (5) setting up community funds for local development. Only in a few countries, a specific tax or a particular tax-rate applies for nuclear installations, including radioactive waste management facilities.
— The limited contextual information gathered for this study indicates that context matters and that the nature, dimension and scope of community benefits are predominantly determined by the social and political context, as well as the needs and requirements of the host communities through negotiations between the implementer and the host community. These negotiations in all cases form, in one way or the other, an integral – albeit not necessarily formal – part of facility siting procedures, running in parallel with site investigations and feasibility studies. In most cases, negotiations on community benefits are concluded before licensing.
— The processes that concerned parties go through to negotiate benefits and define added value are crucial in determining whether or not such benefits (quantifiable or not) are seen as appropriate by all concerned. Through these processes, relationships are built which have an impact on the perception of appropriateness of the agreed benefits for that specific situation.

2.3. Multinational approaches

It is generally accepted that the ultimate responsibility for ensuring the safety of spent fuel and radioactive waste rests with the government of the country in which it was generated. This does not mean, however, that the fulfilment of national obligations through collaboration with other countries should be precluded. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management states “that, in certain circumstances, safe and efficient management of spent fuel and radioactive waste might be fostered through agreements among Contracting Parties to use facilities in one of them for the benefit of the other Parties, particularly where waste originates from joint projects”. With this recognition, the IAEA published in 2016 a report [11] that described a phased approach and indicated the decision processes to be followed by partners in the multinational project to realize a shared disposal facility, both within a national context and in the scope of the joint endeavour, touching on a wide range of legal and institutional aspects, including the contractual obligations among partners; economic and financial arrangements; liabilities; nuclear security; regulatory and legislative aspects; waste transportation arrangements and social matters. The uncertainties and risks involved in the implementation of a multinational repository are also addressed.

Members of EDRAM are implementers of geological disposal of higher radioactive waste in their respective countries established in accordance with their national policy and responsible to realize DGR(s), promoting research and development necessary for attaining their mission and selection of a repository site based on a strategy for the management of their radioactive waste specified by the government. Some of them have established authentic interactions with communities embracing trust and transparency as a critically important organizational priority and have been successful in forming strong bonds of trust with local populations. Therefore, EDRAM believes, though recognizing the involvement in a multinational repository project should be as one of the options in a national policy and strategy, that a successful implementation within

the next 10-20 years of some advanced national programmes should be a top priority as it will be a showcase for institutional and technological success in the management of higher radioactive waste.

2.4. A proportionate approach to radioactive waste disposal

As far as the long-term management of higher activity radioactive wastes is concerned, geological disposal is the only acceptable option, and will be required regardless of the introduction of treatment options such as partitioning and transmutation. However, a number of countries have identified a proportion of their waste inventory that, whilst being unsuitable for surface disposal, may not require geological disposal at depths greater than 200 to 300 meters.

EDRAM accepts that such an approach to the management of radioactive wastes is appropriate subject to the following considerations:

— Any disposal concept should be based on provision of safety functions appropriate to the degree of isolation and containment required for the radioactive waste over suitable time scales.
— When defining the disposal concept, a number of means such as the site characteristics, the waste forms or the engineered barriers system can be called on in order to adequately satisfy the above-mentioned requirements.
— In particular the selected depth of any disposal facility contributes to the degree and duration of isolation and of protection from surface erosion due to effects such as glaciation.
— The depth of the disposal facility also plays an important role in reducing the likelihood of human intrusion.
— Existing surface disposal facilities may not provide the safety functions needed for long-lived radioactive waste. By extending the depth of facilities below the ground level as needed, the degree and/or duration of isolation, protection from natural surface processes and potentially containment can be enhanced. Such facilities could then be suitable for the disposal of material that would present a relatively low hazard, with regard to their radiological inventory, such as irradiated graphite, some operational waste and decommissioning wastes.
— Though any approach will need to demonstrate compliance with the applicable safety standards, this proportionate approach can optimize the implementation of radioactive waste disposal solutions.

2.5. Partitioning and transmutation on the long-term management of HLW

A number of countries are publishing study reports on the alternative management strategies for long term management of HLW including partitioning and transmutation as in the case of Finland [12], France [13], EU [14], Sweden [15] and UK [16], often within a framework of environmental impact assessment. Based on the arguments presented in these reports, EDRAM draws the following conclusions:

— Minor actinide partitioning and transmutation is technically feasible, but there are considerable technological uncertainties to address, and major R&D investment would be needed both by the international community and by individual countries wishing to implement it.
— Transuranic elements contribute largely to the radiotoxicity of HLW, but they have only a minor impact in terms of long-term radiological risk. Therefore, minor actinide partitioning and transmutation does not displace the need for geological disposal: the transmutation option must be considered as a possible complement, but not a substitute for waste disposal.
— The long-term radiological risk results from a limited number of fission and activation products. Although there are scenarios where a strategy of separating minor actinides for recycle can reduce the geological disposal footprint, the benefit of transmutation on the radiological risk of geological repositories remains to be demonstrated, considering that advanced nuclear technologies used for the implementation of the strategy will also produce high-level and long-lived wastes, which will have to be managed in the long-term.
— Partitioning and transmutation can only be applied to elements contained in future waste; it is not realistic to consider such a process for vitrified high-level waste produced to date.
— The transmutation of transuranic elements requires a major investment by the entire nuclear industry of both economic resources and research and development into new technologies and their

industrialization.

— A transmutation system comprises not only fuel reprocessing and fuel production units, but also advanced (high flux) reactors or accelerator driven systems that have not yet been developed. The capacity of the separation technology to provide the high level of purity required for transmutation and the ability of such a system to stabilize and reduce the overall amount of transuranic elements are yet to be demonstrated.
— Regardless of the technologies applied, transmutation is a slow process; the stabilization of an inventory of transuranic elements will take decades. Furthermore, in the framework of the present-day technical transmutation approach, curium is no longer considered because of the associated difficulties. Maintaining curium in high-level waste will significantly reduce the benefit of transmutation in terms of radiotoxicity.
— A partitioning and transmutation program can only be justified by ambitious goals in terms of reducing the radiotoxic inventory of radioactive waste. Only a very good global efficiency of the transmutation system could allow reaching these goals.
— It is necessary to follow up national and international developments concerning the partitioning and transmutation technologies cautiously as the reduction in the radiotoxic inventory of waste may constitute a favorable element for the societal acceptance of the disposal facility, as well as for the reduction in its footprint by reducing the heat load of the waste.

2.6. Cost for geological repository projects

The correct assessment of future costs for geological repositories is an important aspect of radioactive waste management. Nuclear power generators have been and are collecting funds for future costs of managing the waste from their nuclear power generation from the users of nuclear power including the fees for the costs in the current price of electricity. As no geological repository for civil high-level radioactive waste and spent fuel is in operation yet in the world, the future costs need to be estimated. As the time differences between revenue generation and future expenditures can extend to over a century, it is crucial to have a sound methodology for the estimation to minimize the risk of transferring financial liabilities to future generations.

EDRAM established a working group [17] and asked to define tools and basic guidelines for the comparison of cost assessments of geological repositories, reviewing how the responsible authorities/companies in ten EDRAM countries handle the management of radioactive waste issue, including how the economic and financial aspects of the process are dealt with and where the money comes from. The study showed that while national policy and legal frameworks for repositories was broadly similar in these countries, specific circumstances directly relevant to comprehensive cost estimation and evaluation of available financing schemes were very different. These differences include the responsibilities and obligations concerning these issues of the waste producers, the waste disposal implementers and the regulators.

Other important considerations impacting on costs are the repository design (characteristics of rocks and depth of repository), its disposal capacity, annual receiving capacity and planned operating life time. Important factors bearing on the choice of an appropriate financing scheme include the charging arrangements and the application of the ‘polluter pays’ principle for repository and for related waste management tasks including interim storage of waste to be disposed of and necessary R&D activities. Payment timing; fund management responsibilities and investment policy; and methodologies for estimating costs and considering contingency margins that should be added to reflect the maturity status of the projects and their associated technologies uncertainties over the full repository life cycle could impact on cost significantly, though vary from country to country.

Comparing cost estimation methodologies on an international level may be a means to achieve global improvement, making comparisons is, however, not an easy task as every country is responsible for managing its own waste and a multitude of first-of-a-kind projects on various scales are to be taking place in different geological environments and in different societies with different economies.

The activities of this working group are still in a trial and error phase: the group is trying to make a break-down of the cost estimations in a standardized costing matrix that compares significant scopes of the programme consistent with the phases of the programme, expecting that this break-down allows comparing the economic aspects of the different programmes. However, the cost data are distributed over the involved quantities of SF,

HLW and ILW, according to keys based on dimensions data of geological repositories. This distribution is important, as some countries only dispose spent fuel, while some countries only dispose high-level (vitrified) and intermediate level waste, and other countries co-dispose of SF, HLW and ILW. At present the working group concludes that a simplified comparison of cost assessments for geological repository projects is not possible or would produce distorted conclusions. A sound comparison implicates a deconstruction of the cost estimates based on a good knowledge of repository designs for each waste inventories.

2.7. Knowledge management

EDRAM recognizes that the IAEA has been developing several new initiatives of knowledge management (KM) focusing on supporting Member States in their efforts to transfer and preserve knowledge, exchange information, establish and support cooperative networks, and train the next generation of nuclear experts, as many of nuclear organizations in the world face with challenges due to loss or lack of experienced staff, as decisions affecting safety and performance of nuclear power plants and wider stakeholder acceptance thereof must be made using the best knowledge and information available. The basic approach of KM is to utilize information technology (IT) for accomplishing effective use of knowledge and information, including such knowledge that forms best practices and lessons learned. As such knowledge is the result of human and organizational creativity/learning, KM activity should include aspects of learning and creation of knowledge as well as knowledge sharing and communication.

Reviewing recent international initiatives in the field of knowledge management from the waste management organisation (WMO)'s perspective, EDRAM recognized the need for:

- Developing a collective capacity aiming at addressing the full scope of the knowledge ecosystem;
- Dialogue between WMOs to facilitate the collective long-term learning and competences sourcing;
- Collectively managing knowledge by steering cognitive flows, and setting-up processes for capitalizing knowledge (capture, retention, sharing, access, reuse and update within each phase) in order to ensure its transfer to the next phases of the projects.

EDRAM recently established a working group with a view to sharing experiences on developing and implementing KM strategies in these respects for preserving knowledge capitalized across five or more generations and used to inform major programme decisions.

3. CONCLUSION

Believing that international expertise, experience and collaboration are of great value and lead to better solutions for geological disposal of SF and HLW, EDRAM regularly exchanges information among us so as to deeply understand our differences and commonalities from technical and industrial points of view. And it prepares notes of our common understanding or position papers based on such discussions for communicating them with international organizations and international communities, taking opportunity of international gatherings such as the present conference. Topics taken up in this presentation were mainly those related to siting and social acceptance. But it should not be understood that those topics were central issues for the progress in the implementation of geological disposal. Implementation itself includes many challenges: to obtain permissions to construct and operate the repository from hosting community as well as regulatory body, promotion of design and engineering, project management, human resources development, knowledge management etc., which spread over a century. EDRAM will continue to communicate its views on these challenges with international communities as a representative of implementers' community, giving broader presentation, when necessary.

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