

ISSUES FOR THE LONG TERM MANAGEMENT OF RADIOACTIVE WASTE**T. Schneider*, C. Schieber*, S. Lavelle****

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Introduction

High-level radioactive waste are currently managed in interim storage installations, providing an adequate protection of the public and the workers for the short term period. However, the long-term persistence of the radioactivity of the waste gives a new timescale dimension, never experimented by the society for the development of protection systems.

In the framework of the European Commission research project "COWAM-2" (COmmunity WAsTe Management¹) dedicated to the governance of radioactive waste management, the issues of "long term governance" have been addressed by exploring the elements which can contribute to a better integration of the technical and societal time dimensions, taking into account technical, ethical, economic and organizational considerations. The originality of this project is to address the various issues within working groups involving stakeholders from different origins and European countries together with a research team.

After a discussion on the time dimensions to be taken into account from the technical and societal perspective, this paper presents, mainly based on the findings of the COWAM-2 project, a brief analysis of the ethical criteria to be considered when future generations are concerned as well as some performance criteria regarding long term governance. Finally, it proposes a discussion on the interest for the radiation protection experts to engage a process with stakeholders concerned by radioactive waste management in order to favour the emergence of a sustainable management responding to the issues at stake and including radiation protection considerations for long term periods.

1. Long term periods in technical and societal perspectives

From a technical point of view, different timescales are considered in order to assess the safety of the various options for managing radioactive waste. Among the different waste management options, the consideration of timescale is a key feature of the geological disposal option. Therefore, for this option, in a preliminary evaluation of its normal evolution in time, four characteristic periods or phases are usually identified, during repository operation and after repository closure [1]:

- The operational phase: this is the period between waste emplacement and repository closure, and it can last several decades.

¹Web site: <http://www.cowam.org>

- The thermal phase: during this phase, the heat generating waste significantly increases the temperature in and around the repository; its duration is approximately 300 years for vitrified waste and 2 000 years for UO₂ spent fuel.
- The isolation phase: during this phase, the radionuclide releases from the disposal system are negligible; in case of deep geological disposal of high level waste in the Boom Clay, this phase is situated between 1 000 and 10 000 years after the repository closure.
- The geological phase: here the repository enters the geological timescales (10 000 till million years after closure); the main estimated impact, both due to non-retarded and retarded radionuclides is situated in this phase.

It is usually planned to site radioactive waste repositories in stable geological environments in which key characteristics that provide safety, such as mechanical stability, low groundwater flow and favourable geochemical conditions, are unlikely to change significantly in the course of time. Over long enough timescales, however, even the most stable engineered materials and geological environments are subject to perturbing events and changes [1]. These events and change are subject to uncertainties, which generally increase with time and must be taken into account in safety assessments. Eventually, but at very different times for different parts of the system, uncertainties are so large that predictions regarding the evolution of the repository and its environment cannot meaningfully be made (see Figure 1).

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Figure 1. The limits of predictability of various aspects of a geological disposal system

Due to the uncertainties, the safety indicators used for the evaluation of the performance of a geological disposal evolve with the time period under consideration:

- During an initial period where the radionuclides are totally (or near totally) contained in the waste matrix, the evaluation of the performance is based on the integrity of the physical containment of waste.
- When the physical containment can no more be considered as an efficient barrier, it is necessary to evaluate the doses / risks (hypothesis and models used being supported) and to verify that they respect the objectives set up by the safety and radiation protection authorities. The question is then on the reference values to be chosen for these objectives.
- Finally, when these factors are no more considered as reliable (notably when the geological stability cannot be guaranteed), the performance is usually evaluated on the residual radiotoxicity of the waste.

These elements show that the time dimension taken into account within the technical evaluations of safety for the geological disposal option and according to the radioactivity content of the waste are outside the current field usually considered for the prediction of the evolution of the society. For an interim storage option, the situation is different and refers to several decades or centuries. Nevertheless, there is still the question of the long term options and transmission of management systems to future generations.

Asking the question of long term governance from the societal point of view cannot be envisaged as defining how the society (and future generations) will have to be organised in several centuries (or thousands of years) for the management and surveillance of the radioactive waste installations [2].

Furthermore, given the potential risks associated with radioactive waste, and especially the time dimension of these risks, it is essential to acknowledge that the whole society is concerned by this issue and not only the waste producers or the institutions in charge of managing the waste. Of course, the waste producers, the waste operator and the authorities are responsible for the implementation of the waste management options but it is the whole society which is embarking into a long term waste management process, and which has a role to play in order to create the conditions for the future generations to continue this management, to maintain and organise the surveillance and the conservation of the memory of the waste installations.

These management processes or governance processes may evolve with time, but the current generation needs to consider how they can be set up in order to achieve a number of "missions" which will be transmitted to the next generation. That will be the responsibility of the next generations to continue and/or reconsider these processes and to adapt them with the aim of ensuring the realisation of these different missions.

2. Setting in place a long term governance process

2.1. Ethical issues

The consideration of intergenerational issues in the framework of radioactive waste management implies to question not only technical aspects, but also ethical, organizational or political dimensions. These questions are not new, and, particularly for the ethical ones, they have been explored within the radioactive waste management community (like for example the Nuclear Energy Agency (NEA) of OECD [3], the Swedish Consultative Committee on Radioactive Waste Management (KASAM) [4], or the International Atomic Energy Agency (IAEA) [5]). One of the main conclusions of these investigations is to consider that the driving principle for the elaboration of waste management options is to avoid "undue burden" for the future generations.

Within the European COWAM-2 Project, the developments regarding ethics were devoted to the preparation of guidelines for long term governance process for different waste management options. In that sense, these developments were oriented towards the creation of the best conditions to favour the transmission to the next and following generations of the whole waste management system. This led to the identification of three major ethical principles as key issues for the long term governance of radioactive waste: responsibility, justice and democracy [6]. These principles have been analysed by the stakeholders

participating to the project in order to formulate ethical criteria specific to radioactive waste management to be used as aiding tools to evaluate on an ethical ground the various technical processes which can be proposed. Some of these ethical criteria are presented below.

Long term responsibility

The issue of long term responsibility, especially in the case of radioactive waste, suggests that there is no reciprocity between generations. Indeed, the generation n will no longer be alive at the time of generation $n+50$, even if its actions can have long term consequences. But the lack of reciprocity is not a reason for putting aside any responsibility, and on the contrary, it is an opportunity for creating a new kind of responsibility between generations. Among the ethical criteria formulated according to the responsibility principle, one can note the followings:

We should provide the future generations with some appropriate sustainable means (processes, money, institutions, knowledge, know-how,...) for the assessment of radioactive waste repository systems and the protection of health and environment.

We should design an appropriate policy, organization or network able to keep information, knowledge and skills about radioactive waste sustainable and available for the actors and for the education of the future generations, so that they can make the relevant decisions about the future of waste.

The implementation of such criteria implies to address various issues such as:

Ownership: Who is the current owner and who will be the future owner of radioactive waste and sites? What are the conditions at present and for the future for the legal and financial responsibility? Who will be held responsible in case of further damages?

Surveillance: Who is in charge of the maintenance and the surveillance of the repositories? Is the need for technical maintenance and surveillance coherent with the duration of institutions?

Education: How to transmit knowledge and skills on radioactive waste management through generations?

Long term justice

Justice is an evaluation of actions on the basis of a principle of equality or proportion as far as the relationship of individuals to the community is concerned. The issue of long term justice suggests that a generation n responsible for the increase of waste must give a proportionate contribution for the people affected by the waste. The people can belong to the same generation n (local people), or to future generations (for instance, $n+50$). This leads to ethical criteria such as:

The local populations and municipalities should be entitled to socio-economic development funding for accepting radioactive waste on their territory in order to ensure a sustainable development of the territories and to maintain the vigilance of local population and the surveillance of the site.

It is important to realise that the issue of the recognition of the effort of a local territory accepting the waste and the question of the solidarity of the nation will not only be solved with the financial contribution to a sustainable development of the region. There is also a need for a sort of "moral" recognition to be built among generations and through generations, using various means like the empowerment of citizens, the consideration for their demands or the recognition of their role in the long term process.

Long term democracy

Democracy (*demos*, people, *kratos*, power) is a political regime which legitimacy lies in the representation or the participation of the people into the collective deliberation and the decision-making process. Regarding the long term governance of radioactive waste, the following ethical criteria are proposed:

We should favour the political empowerment and the democratic control of the citizens through generations over the institutions in charge of the radioactive waste by an independent organization warranting the continuity of participation and the plurality of expertise, of information and of conceptions and values.

We should ensure that all citizens are provided with the means and information needed to fully participate in the process and to exercise their rights.

We should ensure that the issue of radioactive waste is scheduled regularly on the political agenda of governmental and non-governmental organizations at local, national and international levels, so that it remains a permanent topic in the democratic debates.

The need to elaborate a democratic process ensuring the participation of stakeholders to the decision making process is thus essential to open the question of radioactive waste management to the non-technical issues and build sustainable decisions including ethical and social aspects. These stakeholders come as well from the local level (elected people, economic actors, members of local commission of information, NGOs,...) as from the national level (State representatives, nuclear industry, waste management organizations, ...).

2.2. Performance criteria for long term management processes

As seen within the ethical principles, the existence of a radioactive waste site for long term storage or geological disposal raises issues in various fields. Some of them have been investigated within the COWAM-2 European Commission Research Project in order to provide, when possible, performance criteria regarding long term management processes.

The main fields of investigations were:

The sharing of responsibility between national and local communities for the long term safety of the repositories. This was studied notably on the basis of lessons learnt from the analysis of the effectiveness of the system put in place by UNESCO for the protection of world heritage sites.

The financial schemes for the long term management of radioactive waste. Various schemes already set up in Europe have been studied allowing to point out key issues in this field.

The elements contributing to a sustainable socio-economic development of the territories, including the issue of vigilance concerning the waste installations. This topic benefited notably from the proposals of MONA, the local stakeholder group set up in the municipality of Mol (Belgium) to discuss the disposal of low and intermediate level radioactive waste with ONDRAF/NIRAS (Belgium agency for radioactive waste), and from proposals formulated during the French National Public Debate on Radioactive Waste Management, which occurred in France from September 2005 to January 2006.

Responsibility over long term periods - Lessons learnt from the protection of UNESCO world heritage sites [7]

The UNESCO convention on the protection of the world heritage, signed in Paris in 1972, set in place a system which established, for a certain number of specific locations, considered specifically significant for humanity, the terms and conditions of management combining concerted action by the international community, the government involved and the local population [8]. Three main characteristics of this protection system contribute to its durability and effectiveness and are of interest for long term radioactive waste management:

The capacity to prevent or identify a failure in the protection system through the organization of a regular surveillance and monitoring.

This capacity is primarily based on the recognition of the existence of an heritage that is common to local, national and international players, and the establishment of a clear division of responsibilities between them over time. Everyday management of a site is handled by a local organization in contact with the local inhabitants. The national level sets up a regulatory framework, provides legal guarantees and makes technical and financial contributions to protection-related actions. At the international level, UNESCO monitors the permanence and durability of the local and national protection actions and initiates procedures in the event of any shortcomings, mobilising technical and financial resources as necessary. Effectiveness also depends on the procedures for listing and monitoring the sites to be protected, which stipulates that the State Parties have the responsibility to ensure *'the identification, nomination, protection, conservation, presentation and transmission to future generations of the cultural and natural heritage found within their territory'* [9]

The capacity to mobilize expertise (from the local, national and international levels).

When expertise is needed for a site protection or restoration, the local and national levels can ask for an international expertise. In this case, the main objective of the international team will be to start a programme for training national or local experts, in order to transmit their knowledge. Moreover, international teams are also very often involving local actors in order to benefit from their experience of the local situation.

The capacity to mobilize financial resources (from the local, national and international levels).

Apart from recognition that responsibility for heritage sites is more the affair of the government involved than UNESCO, the projects that have arisen in the context of the 1972 Convention all recognise the need to link site conservation to sustainable development of the area to encourage the local population to play a positive role in taking care of the site. This integration is fostered by the creation of centres of activity handling both safeguard issues and those relating to development (tourism, and the fostering of intellectual and technical skills for instance). It can also be noted that, when a protected site is "in danger", the Convention plans the mobilization of international resources to guaranty the protection of this site.

Coming back to the long term management of radioactive waste, the analysis of the UNESCO experience points out the need, for an efficient and sustainable protection system, to address openly questions of this type:

What is the distribution of responsibilities between local, national and international levels?

How are local stakeholders involved in the surveillance of the site?

What is planned for the long term monitoring? (who is in charge of the surveillance, reporting procedures,...)?

What could be the interest of an international convention on the "protection of radioactive waste disposal"?

How can each generation address the question of expertise: maintaining, developing or creating knowledge and practices?

How to organise the international sharing of expertise?

How to insert a radioactive waste storage/disposal in a local/regional economic development?

How to ensure that the storage/disposal is taken into account in the territorial development?

How to finance the structure in charge of the surveillance?

How to mobilize international resources?

The financial schemes for the long term management of radioactive waste

The analysis of financing schemes put in place in some European countries for the management of radioactive waste and/or decommissioning allowed to identify the following issues for radioactive waste management:

The location of the responsibilities/liabilities regarding the management of waste should be clearly defined (for the waste producer, the waste management organization or the State). These responsibilities include: the ownership of waste, the responsibility for financing, for building storage/disposal, for surveillance, The transfer of these responsibilities/liabilities over time should be planned in advance.

Several types of financial schemes have been identified: dedicated funds (managed by the waste producer, by the waste management organization or separately by a specific

entity) or provisions on the account of the waste producer. Whatever the adopted system, there is a need for transparency on the cost estimates. The decision-making process for deciding the level of the funds or provisions and its use should be explained, as well as the waste management scenario used to determine the level of the financial needs in the future. In particular, it should be identified if costs like the long term surveillance or the financial accompaniment for a sustainable development of the territories are included in the evaluations.

External audit of the funds or provisions should be done on a regular basis by the State in collaboration with national and local stakeholders.

The financial schemes should integrate financial guarantees to be used if the cost of waste management is higher than expected or if there is a bankrupt of a waste producer.

The financial scheme should comprise specific systems to ensure (as much as possible) that the provisioned money will be available when necessary, several years from now.

The capability of evolution of the fund with time should be studied: How to take into account the possible evolution of the waste management options (reversibility, adaptation to new norms,...)?

Towards a sustainable socio-economic development of territories. – Recommendations from the MONA Belgium partnership – Proposals made during the French National Public Debate on Radioactive Waste Management

The need for a sustainable socio-economic development of the territories accepting the waste, should not be seen only as a way to compensate the territories in a duty of solidarity of the nation. In fact, this development is essential in the perspective of the long term surveillance of the waste repositories. It has been shown in several studies [7], that the continuity of the surveillance relies on the presence in the territories of local population involved actively in this surveillance. If the territories are becoming depopulated by a lack of economic development, the link of the population with the surveillance of the site will be lost. However, the emergence of a sustainable socio-economic development of a territory is not straightforward. In this perspective, there is a need to develop territorial projects, mainly driven by local stakeholders and sustained by local and national political wills.

Among its numerous recommendations regarding the socio-economic development of the territory of Mol [10], MONA proposes the creation of a fund to improve the quality of life of the inhabitants of MOL and the wider region because they face up to the repository at a close range. For them, a fund offers the possibility to respond to the changing of societal needs and makes for a durable and visible link with the repository enhancing an integrated approach. The fund's mission statement proposed by MONA is the following:

The fund is created to improve the quality of life of the inhabitants of MOL and the wider region;

The fund is created to achieve this by implementing a broad range of projects (social, economic, cultural, on environment, health and education);

There should be projects in the short, medium and long term;

The projects must be result-driven and sustainable and must produce long-lasting positive effects in their own field. They must have a broad societal support;

The fund must be managed by an autonomous, independent entity;

The fund should regularly investigate the social/societal needs and then devise strategic goals;

The fund advocates a high-quality operation. The final assignment of projects, the follow-up and the evaluation must occur with professionalism and high quality. To this end the fund will also call upon external experts;

The fund will communicate on a permanent basis about the operation of the waste disposal and the concrete realisation of projects. The fund wants to emphasize constantly the link between the repository and the projects.

In France, a national public debate was organised from September 2005 to January 2006 by the Commission Nationale du Débat Public (CNDP) after the request of the Ministry of Ecology and Sustainable Development and the Ministry of Industry, in the perspective of the preparation of the law for the management of high level radioactive waste, to be adopted in 2006. Among the issues addressed during this debate, the sustainable economic development of the territory where the ANDRA research laboratory is installed was largely discussed [11]. The main proposals in order to ensure this development were the following:

There is a need to address the issue of a "cross-solidarity" between a territory receiving waste installations and a nation involved for the sustainability of the region. This issue will notably be discussed within a local/national committee involving the nuclear industry and research centre together with local elected people.

A key factor for the success of this development is the establishment by the local stakeholders of their own project for the future development of their territory. They have to propose and value their advantages for attracting new activities. This preparation phase will put them in a better position to negotiate with the nuclear industry, the State and other organizations for establishing a cooperation framework.

It is proposed that the law integrates the establishment of a contract defining the respective responsibilities of the different actors (local and national level) regarding the economic development if a sustainable option for the management of radioactive waste had to be adopted in one specific region.

One of the guarantee for the long term surveillance of the installation being the existence of life around the installation, it is proposed to establish a clear link between sustainable development projects and the surveillance and vigilance of the nuclear waste installation. In that perspective, it is mentioned that:

- there is a need not only to keep the memory of the installation, but also to keep and transmit the ability to organise its surveillance;
- this ability implies the existence of competences and expertise, which have to be linked with the local economic development;
- the involvement of local stakeholders in the surveillance of the installation is a key feature of the sustainability of the vigilance on the long term.

3. Interests for radiation protection experts

The previous elements clearly show that the consideration of the timescale dimension of radioactive waste cannot be reduced to the only technical aspects. The ethical, economic or organizational aspects are key issues to allow the society as a whole to embark in a long term protection system. The objective is thus, not to make predictions on the future of the society within several centuries, but to build a sustainable protection system setting the conditions for its efficient transfer to the next generation.

There is an interest for the radiation protection experts to contribute to the building of such a protection system. By listening to the concern of the society regarding long term, they will be in a position to propose not only a physical protection from the waste, but a whole system including long term considerations such as the transmission of knowledge and radiation protection competences, the link between sustainable socio-economic development and the organization of the surveillance, ...

For this purpose, it is essential that the discussions on the radioactive waste management options do not be focussed only on technical and scientific issues for dedicated experts, but be opened to other subjects and other stakeholders of the society. There is a need for an elaboration of a long term "governance" for radioactive waste, based on a multi-level (local, national, international) and multi-actors organization.

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