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Aspects of Governance in the Practical Implementation of the Concept of Reversibility for Deep Geological Disposal

Abstract

The European project COWAM in Practice (CIP) was aimed to lead for three years (2007-2009) a process of monitoring, analyzing and evaluating the governance linked with radioactive waste management. This project, in cooperation with a research group and stakeholders, was conducted in parallel in 5 European countries (Spain, France, United Kingdom, Romania, Slovenia).

In France, the issue of reversibility for a deep geological disposal was introduced in the Act of December 30, 1991 on the possible options to manage radioactive waste. The Act of June 28, 2006 relative to sustainable management of materials and radioactive waste confirmed the option, by calling for a reversible waste disposal facility in a deep geological formation to be designed. The main issue is no longer to justify the adoption of reversibility, but to investigate the practical procedures for its implementation.

The French stakeholder Group[1] involved in the European project COWAM In Practice (CIP) had identified several subjects for investigation:

- The different aspects associated with the practical implementation of reversible disposal: technical aspects, and aspects relative to monitoring, safety and expertise, in terms of legal, financial, administrative and political, etc. responsibility related to the notion of reversibility.
- The stakes of governance related to the processes of assessment and decision-making
- The roles of local stakeholders in these processes.

The analysis conducted by CEPN in cooperation with the French stakeholder group, facilitated by Mutadis, showed that the practical implementation of reversibility aims to maintain a capacity of choice between three options: to continue to maintain the reversibility, to retrieve packages or to initiate the closure of all or part the disposal facility. Maintaining this choice in the long term implies setting up specific institutional, financial and decision-making systems,etc,. that need to be jointly developed in advance by all the actors concerned, be this at local, national and even international level.

[1] The French Group for CIP was formed in 2007 and is chaired by the French National Association of Local Liaison Committees (ANCLI). It is made up of a group of local stakeholders (Local Liaison Committees, associations) and representatives of the Directorate-General for Energy and Climate (DGEC) at the French Ministry of Ecology, Energy, Sustainable Development and Town and Country Planning, the French Nuclear Safety Authority (ASN), the Institute for Radiological Protection and Nuclear Safety (IRSN), the French National Agency for Radioactive Waste Management (ANDRA) and EDF.

Thus, this study revealed perspectives for further study in various areas that could be developed by the different actors (institutions, associations, local actors,…). In particular, further investigations could be carried out in the following areas:

- The political dimension and governance related to the practical implementation of the reversibility ;
- The technical aspects of monitoring the installation and its environment ;
- The financial aspects of the implementation of the reversibility concept.

1. INTRODUCTION

1.1. Context

In France, the issue of reversibility for deep geological disposal was introduced into the process of researching radioactive waste management options by the Act of 30 December 1991 [1] insofar as this Act recommended that research be carried out in an underground laboratory intended for "studying the possibilities of reversible or irreversible disposal" in deep geological formations. The Act of 28 June 2006 [2] relative to sustainable management of radioactive materials and waste confirmed this option for high-level and long-lived, intermediate-level radioactive waste (HLW/ILW-LL) by calling for a reversible waste disposal facility in a deep geological formation to be designed.

It is for this reason that the French Group[2] involved in the European project COWAM In Practice (CIP) has been looking at the issue with a view to identifying, among the various possible subjects for investigation, and studying "aspects of governance in the practical implementation of the concept of reversibility for deep geological disposal: including technical, environmental, social, political, economic, scientific, legal and ethical issues, etc." The UK Group has also shown interest in this issue, which, in the future, may be examined in light of the waste management concept to be opted for in the UK (see Appendix 1).

Research on this subject has been used in analysing and discussing the aspects of governance related to reversibility, in the case of deep geological disposal of high-level and long-lived, intermediate-level radioactive waste (HLW/ILW-LL). Investigation has covered the following issues:

- The different aspects associated with the practical implementation of reversible disposal: technical aspects, and aspects relative to monitoring, safety and expertise, in terms of legal, financial, administrative and political, etc. responsibility related to the notion of reversibility.
- The stakes of governance related to the processes of assessment and decision-making
- The roles of local stakeholders in these processes.

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1.2. Proposed approach

To begin with, the changes in opinions regarding the introduction of reversibility in the design of geological disposal facilities was analysed in light of different international contexts. Secondly, an investigation of the current context in France was carried out on the basis of the regulations and ANDRA publications. This investigation was supplemented by discussions with institutional stakeholders involved in the French CIP Group (IRSN, DGEC, etc.), together with the UK CIP Group, to which the initial research results were presented.

Particular attention was focused on the viewpoints of local actors with regard to the practical implementation of the concept of reversible geological disposal, with three local meetings, organised at the request of the ANCLI, with local actors concerned over the installation of the future disposal facility in the French regions of Meuse and the Haute-Marne and local actors in Nord Cotentin concerned over management of the Manche waste disposal facility [3]. The main objective of these meetings was to draw up a list of the local actors' questions and opinions relative to reversibility, and then to relay these to the members of the French Group.

2. CHANGES IN THE CONCEPT OF GEOLOGICAL DISPOSAL OF HLW-LL AND INTRODUCTION OF THE NOTION OF REVERSIBILITY

2.1. Changes in the concept of geological disposal from the international point of view

The concept of geological disposal for high-level and long-lived radioactive waste (HWL-LL) has undergone a series of changes over the last thirty years, gradually being superseded by the introduction of the notion of reversibility.

2.1.1. Geological disposal is intrinsically non-reversible

Since the 1980s, after various means of waste management had been considered (underwater geological disposal, injection of liquid radioactive waste below ground, etc.), and developed in parallel with containment techniques (including vitrification), geological disposal has gradually been seen as the most suitable option by countries such as Canada, the United States, France and Sweden, as well as by institutions such as the OECD's Nuclear Energy Agency and the International Atomic Energy Agency. Geological disposal is designed to be a permanent and intrinsically non-reversible solution.

This option of irreversible disposal aimed both to avoid leaving an unwarranted burden on future generations (while maintaining institutional monitoring of the site for a limited period), and to reinforce passive safety at facilities.

> *"Disposal is a method of waste management in which waste is safely discarded without the intention of retrieval. The objectives of retrieval are to protect man and the environment and to minimize the burden imposed on future generations for the continued management of the waste."* (Regulatory Document R-71, Atomic Energy Control Board, Canada, January 1985) [4]
>
> *« Disposal means isolation of radioactive waste to make them inaccessible »*, (United States, Code of Federal Regulation Energy, Title 10, Part 60, 1986) [5]

2.1.2. Introduction of the notion of reversibility

Subsequently, in France and worldwide, the conception of radioactive waste management began to evolve, with the introduction of the notion of reversibility as a factor allowing flexibility in decision-making processes.

In France, Act No.91-1381 of 30 December 1991, also known as the "Bataille" Act, after the Rapporteur who drafted it, opened up a broader range of options and, in

particular, called for a study on the possibilities afforded by reversible or irreversible geological disposal.

This Act conferred upon ANDRA the task of assessing the option of deep geological disposal or storage of radioactive waste, indirectly introducing the possibility of reversibility.

> *"The laboratories are in charge of investigating deep geological formations that might be suitable for the* ***disposal or storage*** *of high-level, long-lived radioactive waste."* Art.5. Act 91-1381

2.2. The objectives of reversibility

2.2.1. Reversibility is now seen as an answer to an ethical necessity

Reflections on ethical issues involved in radioactive waste management, led by the CEPN and MUTADIS on behalf of the French Institute for Nuclear Protection and Nuclear Safety (IPSN)[3], have identified the advantages of reversibility as introducing an aspect of flexibility into the decision-making process [6-7].
Implementing a concept of disposal in geological formations that incorporates the possibility of reversing the initial decision is seen as satisfying the ethical necessity of ensuring that the generation that has enjoyed the benefits of nuclear energy provides the means to ensure safe permanent disposal of the waste produced, while leaving future generations the possibility of changing such implementation or reversing the process if they see fit.

Since 1986, the Swedish National Council for Nuclear Waste (KASAM) [8] has highlighted the need to minimise the burden on future generations. It is now seen as preferable not to make decisions for future generations and ensure that they have " *the same right to integrity, ethical freedom and responsibility that we ourselves enjoy."* Their current position reflects this ethical principle while safeguarding future generations from having to take full responsibility for permanent disposal.

[3] The IPSN has since become the IRSN – Institut de Radioprotection et de Sûreté Nucléaire - the Institute for Radiological Protection and Nuclear Safety

KASAM (Nuclear waste state-of-the-art report 1998 [8]): "*The relationship to future generations is not solely determined by considerations of potential risks to life, health and the environment. We should also apply to future generations the same attitudes toward human beings that we consider to be fundamental to the view that we have of ourselves and of our own responsibility*"

KASAM (Nuclear waste state-of-the-art report 2007 [9]): *"A final repository should be con- structed so that it makes inspection and controls unnecessary, without making inspection and controls impossible. In other words, our generation should not place the entire responsibility for the final repository on future generations, but neither should we deprive future generations of the option of assuming responsability"*

It appears from the UK point of view (see appendix. 1) on the issue of reversibility a general "acceptance" of recoverability in the design of disposal in order to potentially provide a benefit of choice for future generations without causing undue burden to the current generation (increase of workers doses, hazardous installations ...) White Paper, June 2008 [10], NULEAF Steering Group [11]

Following on from the publication of the Act of December 1991 in France, Christian Bataille, in a report to the French Parliament (1993, [12]), stipulated that, "*reversible disposal seemed [to him] to provide both a scientific and a moral guarantee (…). Bearing in mind scientific and technological progress, and the advances made in alternative avenues of research, this characteristic guards the possibility and, therefore, the freedom, of choice."*

International organisations share these ethical principles, even though, in 1992, the IAEA's position (1992) [13] did not allow a great deal of leeway for reversibility in relation to the concepts of disposal, noting that the latter consists in "*preserving the rights of the future generations (in order that the) solutions developed today should not be irrevocably applied but should allow for corrective actions if such would appear justified"* Its definition of the concept of disposal in 2006 remains similar to its previous position: "*the concept of disposal means that there is no intention of retrieving waste packages, even though such an eventuality should not be ruled out."* IAEA (2006) [13].

AEN/OCDE (The environmental and ethical basis of geological disposal of Long-Lived Radioactive wastes, 1995 [14]) *"Retrievability is an important ethical consideration since deep geological disposal should not necessary be looked at as a totally irreversible process, completely foreclosing possible future changes in policy" (…) "The incremental process leading to implementation of the geological disposal strategy incorporates the advantages of a temporary storage phase, as advocated by some, without letting this phase extend indefinitely"*

AEN/OCDE (Regulating the Long-term Safety of Geological Disposal, 2008 [14]) "The obligations of the present generation toward the future are complex, involving not only

issues of safety and protection but also of freedom of choice and of the accompanying burden of responsibility, and of the need to transfer knowledge and resources ”.

2.2.2. A flexible decision-making process, and designing staged disposal

Analysis of the social issues related to reversibility highlights the importance, within a complex decision-making environment where the levels of (social and technical, etc.) uncertainty are high, of committing to a flexible decision-making process that allows for the possibility of reversing decisions and maintaining a degree of autonomy for future generations [7]. The aim of this flexible decision-making process should be a move toward the concept of deep storage in stages.

According to the NEA (1999c) [17], "*The growing importance of a staged decision-making process, together with reversibility and retrievability, imply the need to change the design of disposal facilities, which is increasingly viewed as a process that is likely to involve several generations*."
Reversibility introduces a need for flexibility in disposal facility programmes due to this long-term perspective. The objective is now to be able to factor in:

- "*New technical data regarding the sites and design of facilities*
- *New technological developments in radioactive waste management*
- *Changing economic, social and political situations and changes in the level of public acceptance."* (NEA, Stepwise approach to decision-making for long-term radioactive waste management, 2005 [18])

The NEA (2005) [18] specifies that, "*Reversibility should not be seen as a lack of confidence in the ultimate safety of a waste management option, but rather as a desire to make optimum use of available options and design alternatives."*

The amount of time for which geological disposal remains reversible may make it possible to:

- monitor waste and storage more closely
- access packages more easily in the event of any problems
- remain abreast of the conditions for acceptability of the disposal option
- examine alternative options for radioactive waste management (retrieve waste for other uses, or for another management facility)
- organise the transfer of knowledge and techniques to future generations

International texts do not specify the length of the period of reversibility. International studies do, however, insist on the need to implement a stepwise approach to decision-making

At the European level, reversibility has been tackled under the 4th Framework Programme of the European Commission on the subject of "the retrievability of long-lived radioactive waste stored in deep repositories," between 1998 and 1999, the results of which were presented in 2001 [19]. Experts from organisations involved in developing concepts for long-lived waste disposal in nine European countries[4] have

[4] ANDRA (France), NRG and KARUWEEG (the Netherlands), DBE and SCK-CEN (Belgium), ENRESA (Spain), NAGRA (Switzerland), Nirex (United Kingdom), POSIVA (Finland) and SKB (Sweden)

taken part in this concerted action. Together, they defined the notion of reversibility as, "*the ability provided by the repository system, to retrieve waste packages for whatever reason retrieval might be wanted."* Based on this definition, it has become possible to retrieve packages provided that three conditions are met:

- That the waste packages are accessible
- That the waste is confined to the waste packaged
- That it is technically feasible to retrieve the waste packages

This research was completed by a definition of the design, construction, operating, closure and post-closure phases of reversible disposal in thirteen stages.

Stages recommended by the European workgroup on designs for reversible disposal.

1. Interim storage at or near the surface
2. Design and construction of the repository and completion of the first disposal cells
3. Period of filling one disposal cell with waste package(s)
4. Period of keeping the package accessible before backfilling and sealing the disposal cell
5. Backfilling and sealing of the disposal cell
6. Period of keeping the backfilled and sealed disposal cell accessible before backfilling the deposition tunnel
7. Backfilling the deposition tunnel
8. Period of keeping the access tunnel open, after having backfilled the deposition tunnel
9. Backfilling of the access tunnel
10. Period of keeping the access shafts open, after having backfilled the access tunnel
11. Backfilling and sealing the shafts
12. Post-closure phase with institutional control
13. Post-closure phase without institutional control.

2.3. Reversibility in the French public debate

A public debate was held in France between September 2005 and January 2006 [20-21-22] on the issue of radioactive waste management in the broadest sense in view of drafting the 2006 Planning Act relative to radioactive materials and waste management.

Thirteen meetings were held covering three key issues, aimed at identifying people's concerns, clarifying points on which people agreed or disagreed and reviewing the various arguments put forward:

- Public meetings with people directly affected by facilities related to the research
- "Key scientific and technical options"
- "Democracy and radioactive waste beyond 2006"

There was little debate over the notion of reversibility at the various sessions. It nonetheless seems essential to review the main opinions expressed during the different meetings [20] regarding this issue and which partially influenced the Act of 2006:

- The notion of reversibility refers to the issue of scientific predictions over long periods of time.

Yves Mansillon (Chairman of the National Public Debate Commission (CNDP)): "*(…) the population expressed its incredulity with regard to very long-term predictions: no one can possibly know for sure what will happen in a thousand years' time, let alone ten thousand years."*

Associative stakeholder: Michèle RIVASI, Founder of CRII-RAD, the Independent Commission for Research and Information on Radioactivity: "*When I'm told that disposal*[5] *is reversible at 600 m or 450, or 490 m, I'll wait and see, because this hasn't been possible at the disposal site. So, I'd personally prefer to be told that reversibility is possible during the operational phase. Once operations come to an end, I think it becomes irreversible. It might be more honest to put it this way."*

- Changes in ANDRA's discourse on reversibility and irreversibility. ANDRA initially demonstrated that irreversible geological disposal was the safest means of containing radioactive waste and that this had no impact on human health or the environment. Following the introduction of the notion of reversibility in the 1991 Act, ANDRA then introduced reversibility in disposal design, which, according to ANDRA, will remain a safe engineering structure.

[5] Here, the Centre of Manche

Former representative of the ICLI (former acronym of the CLIS, the Local Liaison and Monitoring Committee): "*I was somewhat dumbfounded to see the turnaround in ANDRA's discourse insofar as regards this notion of reversibility and irreversibility.*"

Georges Mercadal (Chairman of the Special Public Debate Commission (CPDP), Report): "*The people that live and work in Bar-le-Duc and Saint-Dizier do not believe that geological disposal can be reversible. The reasoning behind their mistrust can be found in the past history of the matter as they see it: just a few years ago, ANDRA stated that geological disposal was not reversible. Furthermore, repositories are made to be closed since the philosophy underlying the concept is to place our trust in geology, not society. All of a sudden, ANDRA is now declaring that disposal is reversible.*"

- In the flow of comments regarding the turnaround in ANDRA's discourse on reversibility, several people mentioned the inconsistency of the notion of reversible disposal whereas disposal is, by definition, irreversible.

Jean Marc Fleury, Association of Elected Officials in Meuse and the Haut-Marne made a stand against burial: "*Quite simply, because reversibility (…) is not a scientific argument within the context of this solution, because it is inherently understood that this deep geological disposal solution is not reversible. If you want it to be safe, it cannot be reversible.*"

- Several people expressed an opinion in favour of long-term storage

Yves Mansillon (Chairman of the National Public Debate Commission (CNDP)): *"Insofar as concerns long-lived waste, the most noteworthy contribution to the public debate has been the emergence of a potential new strategy. Then the idea of long-term storage emerged, no longer as an interim solution, however long it might last pending disposal, but as an alternative long-term solution."*

- There is strong demand on the part of civil society for the notion of reversibility because it means we can avoid making definitive decisions for future generations.

Jean Marc Fleury, representative of the Association of Elected Officials of Meuse and the Haut-Marne is against burial: "*Reversibility is the politician's argument to make us accept this solution."*

A former representative of the ICLI: *"Studies have shown that reversibility could be ensured for a minimum two or three hundred years." To my mind, it is crystal clear that this is a PR text that has been drawn up under pressure from politicians to try and get the population to swallow the fact that this is a very awkward problem."*

- Research on the conditions required for reversibility is a crucial prerequisite before going ahead with a decision-making process concerning permanent disposal.

The Bure CLIS wants to see "*Attention focused specifically on studying the conditions for reversibility (…),*" and, "*that the conditions of research in the laboratory should be as close as possible to the conditions encountered in a real disposal situation…*"

2.4. Reversibility in the 2006 Act and the related decision-making process

According to the Planning Act of 28 June 2006 [2], studies and research into reversible disposal of high- and long-lived, intermediate-level radioactive waste in deep geological formations are to be carried out with a view to selecting a site and designing a disposal facility so that, in light of the results of the studies carried out, application for authorisation of such a site can be instigated in 2015 and, providing such authorisation is granted, the facility could be operational by 2025.

First of all though, ANDRA must present a progress report to the government in 2009, stipulating[6]:

- An area of interest covering 30 km^2 where the disposal facility could be built
- Options relative to the design, operational safety, long-term perspectives and reversibility
- A model inventory of waste to be dealt with
- Storage options in complement to disposal

After this progress report has been presented, the decision on opening this disposal facility must be taken in line with the process below (described in detail in the French National Radioactive Materials and Waste Management Plan – PNGMDR - published in 2007 [24]):

- Application for authorisation to set up the disposal facility must be preceded by a public debate, scheduled for 2013, and based on a documentation pack drawn up by ANDRA.

- This application for authorisation, to be submitted at the end of 2014, will entail
    - A report by the National Review Board (Commission Nationale d'Evaluation, CNE),
    - An assessment by the French Nuclear Safety Authority (ASN)
    - The gathering of the opinions of local authorities in all or part of the area included in the consultation process as defined by decree.

[6] According to a press release published by ANDRA on 12 June 2008

- The application for authorisation, together with the minutes of the public debate, the CNE's report and the ASN's assessment, will then be submitted to the Parliamentary Office for Evaluating Scientific and Technology Options (OPECST) for assessment. With regard to the gathering of local authorities' opinions, the Planning Act does not give any additional details as to the body to which these will be submitted, nor to the ultimate use of the comments gathered.

- The OPECST will report on these studies to the relevant committees at France's National Assembly and the Senate (2015).

- The government will present a draft bill setting out the conditions for reversibility after consulting the report by the OPECST (2015).

- Once this Act has been passed, authorisation to set up the disposal facility may be granted by Council of State decree issued after a public hearing.

- The disposal facility could be operational by 2025.

3. NATIONAL AND INSTITUTIONAL ACTORS' VIEWPOINTS ON INCORPORATING REVERSIBILITY INTO THE RADIOACTIVE WASTE MANAGEMENT SYSTEM

Whether in official publications (especially as part of drawing up the 2006 Act [25-26-27], at meetings of the French CIP Group or in special interviews, ANDRA, the IRSN and the ASN have expressed their views on the practical implementation of reversibility. In this chapter, we analyse studies by these stakeholders, especially with regard to the decision-making process, the impact on safety and facility monitoring.

3.1. General viewpoint on reversibility

At ANDRA, the notion of reversibility in designing geological disposal facilities introduces a degree of freedom for future generations to make different management choices and to include a progressive approach in implementing these choices. The agency believes that, from a technical point of view, reversible disposal could be ensured for a period of two to three hundred years. [25]

Based on the conclusions of the permanent group of experts for waste and the IRSN's appraisal of the "2005 clay dossier" [26], the "*ASN considers, on principle, that reversibility can only be for a limited period. In fact, accessibility to radioactive waste packages must be limited in terms of time because if closure of the facility is deferred for too long, this might compromise the notion, perhaps even in the long-term, of safe disposal.*" [27]

3.2. Reversibility and the decision-making process

According to ANDRA, it is not a matter of thinking in terms of the length of reversibility but of developing a step-by-step disposal process with flexible management. The steps in the process may lead to a gradual reduction in the level of reversibility, and thus to the progressive closure and an increasingly passive configuration:

Step 1: Construction followed by package emplacement;
Step 2: Closing cells;
Step 3: Closing access to the cells;
Step 4: Closing disposal areas (according to waste category);
Step 5: Closing the disposal facility.

As each step is completed, the need for maintenance is reduced. Reversible disposal could thus play the role of a storage solution and evolve to become a disposal facility that does not require human intervention, thus affording additional safety guarantees in the long term.

According to the IRSN, reversibility entails setting up a decision-making process based

on three alternative principles:

- Maintaining access to the packages
- Retrieval of packages
- Progressive closing of the disposal facility

The question raised is therefore that of defining the means that should be implemented today to ensure reversibility in the course of time and guarantee the decision-making process in the long-term. Moreover, to be able to make decisions, it will be essential to ensure that monitoring and maintenance operations are effective and durable.

The ASN shares ANDRA's vision in seeing the concept of reversibility as not being infinite, in the sense that reversibility presupposes closure at a given time. In its view, the decision to close the facility, and thus to "put an end to reversibility", should, on principle, be taken by Parliament.

3.3. Reversibility and safety

At the ASN and the IRSN, the fundamental principles relative to the permanent disposal of radioactive waste in deep geological formations are that the provisions set down to ensure the reversibility of disposal should, under no circumstances, compromise:

- Safety during the operating phase of the disposal facility
- Safety once it has been closed

However, according to both the ASN and the IRSN, prolonged opening, and, therefore, long-term accessibility to the packages, could entail risks in terms of disposal facility safety. Opting for a design that integrates reversibility implies using different technical options to those used for irreversible disposal. This implies designing a complex storage facility.

Among the consequences of a design that integrates reversibility, the IRSN believes that it is important to factor in the following aspects:

- The environment of the packages will vary depending on whether the disposal facility is closed or remains open. As long as the disposal facility remains open, the packages will evolve in an oxidising environment liable to increase the risk of radiolysis and explosion. Whereas, in a closed disposal facility, the packages evolve in a reductive environment.

- Creating galleries that remain accessible will heighten disturbance of the geological environment compared with a design that is "irreversible" from the outset. The longer the disposal facility remains open, the more the environment will be disturbed.

- A different design is required for the packages. To enable them to be retrieved, the design of the packages must include containers that can withstand long periods of time so that they can be handled at any time. If a more substantial container is used, a more voluminous quantity of metal will be present in the

disposal facility. This element affects the chemical, physical and mechanical disturbance of the geological layer and may impact on the long-term safety of the disposal facility.

In addition, the IRSN notes that, depending on how long reversibility is maintained, it is essential to be vigilant over keeping and sharing information (archiving and document management) that may affect safety in the long term.

Also, the probability of intrusion into the disposal facility should be the same whether it is "open" or closed. On the other hand, the risk associated with this intrusion will be much greater when the facility is open.

As for package safety, if everything is designed with a view to causing as little disturbance to the rock as possible, the packages must remain in a good state of conservation over the long-term. Upstream inspection of the packages is currently so rigorous that it effectively guarantees the safety of disposed packages. The major risk would be dropping a package.

3.4. Reversibility and monitoring

According to the ASN, active monitoring and maintenance are required throughout the period of reversibility to "*avoid abandoning the disposal facility before it is closed.*" The IRSN adds that the real challenge in implementing reversibility is to ensure vigilance, which is wholly dependent on the sustained transfer of knowledge, i.e. in maintaining professional skills and organisational control of the system.

According to the IRSN, since reversibility implies being able to retrieve packages in safe conditions and being able to know what is happening before re-opening the disposal facility, a special monitoring system must be set up. As for any Basic Nuclear Installation (INB), the safety file for the future facility is scheduled to be re-examined at regular intervals (every 10 years, for example) during the operational phase. As long as these checks are scheduled (and performed) and maintenance operations are implemented, the length of the period of reversibility (100, 200 or 300 years) is not that crucial a safety factor[7]. Thanks to these different scheduled checks, it should be possible, if necessary in line with developments in safety criteria, to bring equipment up to standard (and even replace obsolete equipment) and make adjustments to the facility in line with future safety requirements. This would also provide an opportunity to raise the question of whether or not to maintain reversibility.

[7] Even though the IRSN believes that it would be much too complicated, given the current state of research, to guarantee a specific period of reversibility, ensuring that packages can be retrieved after the facility has been open for longer than 300 years (IRSN opinion on ANDRA's “2005 clay dossier”).

Several types of monitoring need to be taken into consideration:

- Monitoring the environment, intended to check and adjust predictive models of environmental change. This could be performed from the surface using sensors placed within the environment. This type of monitoring will be performed regardless of whether the disposal facility is reversible or not.

- Monitoring waste package integrity. Low-level waste packages require close monitoring. Very high-level waste packages must be monitored by camera. Such monitoring will last for as long as the possibility of retrieving the packages is to be maintained.

Performing inspections of packages and equipment upstream, together with safeguarding the "culture of surveillance" will help improve quality at the disposal facility.

4. STUDIES OF ASPECTS OF GOVERNANCE IN THE PRACTICAL IMPLEMENTATION OF REVERSIBILITY

The research group's investigations were carried out by drawing firstly on the results of the European COWAM 2 project [28] relative to taking account of monitoring in the long-term and maintaining it and, secondly, on interviews with the members of the French CIP Group and local players [3]

These investigations have revealed elements in the decision-making and assessment processes related to the practical implementation of reversibility, focusing more particularly on the role and the expectations of local actors in this context.

4.1. Proposed framework for studying governance procedures for reversibility

In light of developments in studies of the notion of reversibility in the design of geological disposal facilities for radioactive waste, at the international level and in France, it is now acknowledged that introducing a period of reversibility will allow for flexibility in the decision-making process and leave the options open for future generations.

In France, reversibility is now included in the Planning Act of 28 June 2006. The key study needed is not, therefore, on the justification for adopting reversibility but rather to investigate the practical procedures for its implementation, in technical terms as well as in terms of the related social, economic and political, etc. aspects.

From a practical point of view, the aim of maintaining a period of reversibility is to be able to choose, throughout this entire period, between three major options: continue to maintain reversibility, retrieve packages or initiate the closure of all or part of the disposal facility. These options would be, for example, discussed at meetings with the Administration. The issue of decision-making criteria for choosing which option to implement is not currently discussed. It will be down to the future generations affected by these decisions to draw up their own decision-making criteria in view of the context in the future.

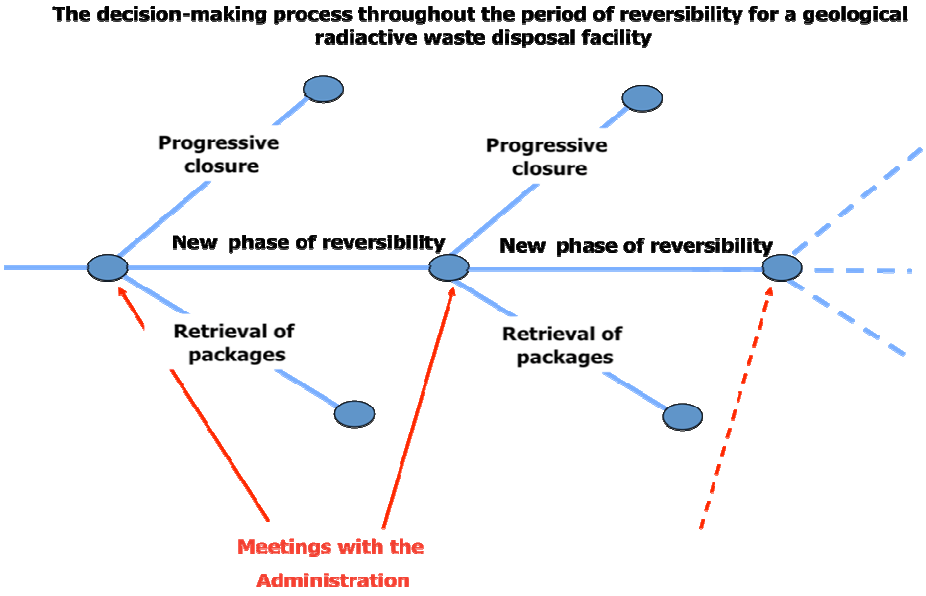

Figure 1. Illustration of the decision-making process throughout the period of reversibility for a geological radioactive waste disposal facility

The issue of the practical implementation of reversibility requires looking more specifically at the decision-making and assessment process, which implies undertaking studies focusing on:

- Governance, in terms of decision-making and responsibilities
- Maintaining monitoring and vigilance throughout the period of reversibility
- Developing citizen competence and sharing expertise
- Keeping the memory alive and passing it down through successive generations
- The means of financing the waste management system and reversibility

4.2. Decision-making process and responsibilities throughout the period of reversibility

Given that the period of reversibility is seen as a period during which three options must be kept open - maintain reversibility, retrieve waste packages or (progressively) close the facility - it is essential to **determine the structure of the decision-making process associated with these options**: Who will be involved in assessing the situation? Who will make the decision? How often will the situation be reviewed? etc.

Role of local stakeholders

From local discussions, it appears that there is **strong demand on the part of local actors to be involved in the decision-making process**, not to take the decision themselves but to **be involved in assessing** the disposal facility and ensuring that their expectations, especially insofar as their concern decision-making criteria, are effectively taken into account.

The ways in which local actors will be involved still need to be defined. Reference has often been made to the need to network local actors together to ensure they are adequately represented. Local networking in the form of local liaison committees (CLIs, or *Commissions Locales d'Information*) or national networking would most likely fulfil this objective. **However they are involved, for this to be effective and sustainable will depend on the influence that the local actors can really exert on the final decisions taken at national level**.

The involvement of local actors in actually drawing up the assessment and decision-making processes will also serve to make it more effective and, thereby, make the decisions taken more sustainable.

Integrating long-term dimensions

Since the period of reversibility extends across the medium or the long term (remember that a period of at least 100 years is currently planned in France), it is important to **examine the capability of maintaining regular debate over the future of the disposal facility over time**.

The COWAM 2 project [28] has shown that the involvement of one (or more) international institution(s) would be likely to promote sustainability by acting as a relay in the event of a loss of vigilance at national or local level, or during periods of social change. It is therefore necessary to **examine the possibility of involving the international level in to the assessment and decision-making processes** relative to the practical implementation of reversibility.

The issue of the long term also raises the **question of how new developments in standards should be taken into account** (safety standards, radiological protection standards, environmental protection, etc.) and **how to ensure the capacity of technical and organisational systems** to adapt to such developments. Organising **regular meetings**, within the framework of the decision-making process related to reversibility, to decide between the options for the future of the disposal facility **serves to highlight this question and favours implementation of the resulting actions** (e.g.: renewing equipment inside the disposal facility in line with new regulations and new techniques, etc.).

Viewpoints of some of the actors regarding the decision-making process

Taking local actors' expectations into account

Even though they have been provided with opportunities for discussion, many local actors deplore the fact that their expectations are ultimately accorded little weight in the decisions taken at national level relative to radioactive waste management in their local areas.

Regular meeting points
On this subject, the IRSN noted that, at the moment, meetings between the operator and the administration are scheduled to take place every 10 years to review the safety reports.

Institution in charge of the decision to close the disposal facility
The ASN's view is that final closure of the facility will no doubt be voted on by Parliament.

Credibility of the option to retrieve packages
Many people asked about the possible retrieval of waste packages. It would be useful to consider this possibility now, by examining the alternative techniques and funding mechanisms required to implement this option, especially since retrieving waste packages is not, for the time being, provided for in the requirements for radioactive waste producers.

4.3. Monitoring and vigilance

The monitoring plan associated with a reversible disposal facility includes specific aspects, such as:

- maintaining a capacity of choice
- the health and environmental impacts
- the inventory of the contents of the disposal facility
- etc.

The continuity and durability of such monitoring in the long term cannot be guaranteed nor decreed. This means that we need to examine how to create the conditions to foster the preservation of such vigilance (at local, national and international level), as well as its transfer down through the generations.

Maintaining a capacity of choice
To ensure that the ability to choose between the three main options is maintained over the course of time, an adequate "surveillance programme" needs to be established. Setting up such a surveillance system is based on the involvement of the local stakeholders in the **definition and the follow up of meaningful indicators for assessing the three options** that, in particular, make it possible to **assess the evolution of the waste packages and engineering structures**, to **assess the capacity to retrieve any or all of the packages**, to **evaluate the associated radiological impact** (on workers, on the public and on the environment), etc. This joint surveillance programme could improve the confidence of the local stakeholders in the assumptions used in the safety analyses and to reduce the uncertainties in the assessment.

Following-up the environmental and health impacts

The discussions held with the various actors reveal a demand for special monitoring of the disposal facility's impact on human health and the environment. Again, to ensure

this, stakeholders should be involved in the elaboration of meaningful, relevant, indicators.

The component parts of this type of surveillance programme could be developed, in conjunction with local actors, **by defining a reference point and by drawing on existing feedback** on environmental and health monitoring, and, in particular, on:

- studies carried out by the Nord Cotentin Radioecological Group (GRNC), initially formed to assess the risk of leukaemia caused by radiation from the nuclear facilities in the region, and which is pursuing its work in assessing the environmental and health impact of chemical substances [29-30] ,
- cancer register set up by the Local Liaison Committee for the Gard,
- the experience of the British COMARE committee (Committee on Medical Aspects of Radiation in the Environment), initially set up in 1986 [31] to carry out epidemiological studies on the risk of leukaemia for people living in the vicinity of Sellafield, and which is now pursuing a more general assessment of the effects on health related to ionising radiation, while carrying out specific investigations into the risk of child cancer in the vicinity of nuclear plants in Great Britain [32] .

Following-up the waste inventory

A **special tracking system** involving the local stakeholders **must be set up to follow-up** the contents of the disposal facility, throughout the entire operational phase and subsequently **maintaining this knowledge in the long term, ensuring that it is passed on to future generations**. The issue of keeping an inventory of all radioactive waste contained in the disposal facility is raised at various levels, including:

- From an ethical point of view, ensuring that the memory of the inventory is kept alive over the course of time is seen as a duty of today's generation toward future generations, who have a right to know of the legacy we have left them;
- From the technical point of view, keeping the option of retrieving packages open makes it even more essential to know exactly what the facility contains;
- With regard to risk management, it is essential to know exactly what the contents of the disposal facility are in order to be able to assess, over time, the potential impact on health and the environment related to the facility.

Inventory monitoring indicators must cover **not only the radiological contents of packages**, but also include data on the potential presence of **chemicals**, **package design**, how they are positioned in the facility, etc. Also, to **increase confidence in the inventory** drawn up, many actors feel it is necessary that **this inventory is checked by a pluralistic body (or bodies)**, in other words, by a body that includes not only the producers of radioactive waste and the disposal facility operator, but also representatives of other institutional and non-institutional actors (safety authorities, the IRSN, associations and local actors, etc.). Lastly, in order to improve the pertinence of the indicators defined and to identify the factors involved in maintaining and

transmitting the inventory over the course of time, it is essential to learn lessons from past experiences in waste disposal (radioactive or chemical waste)[8].

Involvement of local actors

The period of reversibility is most suitable for close monitoring of the packages, structures and the environment. This period is of **particular interest for local actors** insofar as it can be used to **set up a monitoring and vigilance system that will help improve confidence in the safety scenarios or to clear up any doubts and uncertainties.**

The best way to satisfy this need, make use of the meaningful indicators and encourage the results to be taken on board, is that the **monitoring plan and all the various surveillance indicators be developed in conjunction** with all the different actors (local actors, operators, industrialists, institutions and associations, etc.)**.**

Points of view expressed by some actors regarding surveillance and vigilance

The opportunity afforded by reversibility
Reversibility is seen by local actors as an opportunity worth seizing to plan monitoring, tracking and safety at the facility more effectively.

Circulating the results of monitoring
The High Commission for Transparency and Information on Nuclear Safety (HCTISN) recommends that the operators of former radioactive waste storage sites should regularly present the inventory of all substances stored at the site to the CLIs, together with the results of monitoring their impact on the environment, the measures taken to reduce their impact and the relevant schedules, as well as holding discussions between the stakeholders on issues related to such sites [33].

Inventory of the disposal facility contents
Some local actors in Nord Cotentin highlighted uncertainties surrounding the contents of the low level waste disposal facility of Manche (CSM): some waste is recorded properly whereas absolutely nothing is known about other waste, which usually dates from the time that the facility started operating.

Members of voluntary associations believe that, in the case of the Bure disposal facility, it will be necessary to define in precise detail the kinds of packages emplaced there, in what proportion, what they contain and what their volume is.

[8] In particular, the following experiences were mentioned at the local meetings: radioactive waste disposal in Asse, Germany, the Manche disposal facility and the low and intermediate level waste disposal facility in Aube, in France or in Habog in the Netherlands, together with the chemical waste disposal facility in France (Stocamine).

4.4. Keeping the memory alive and passing it down through successive generations

The issue of keeping the memory of the facility alive and passing it down through future generations is a key factor in managing the reversible disposal facility in the long term.

Transmission of the memory in the perspective of vigilance

A **distinction has to be made between "passive" memory and "active" memory**. The passive memory is made up of all the archived documents that can be used to track the history of the disposal facility, its design and contents, and the results of environmental monitoring, etc. **The durability of the passive memory depends mainly on information redundancy and the location of the archives.**

Nonetheless, this memory is only useful for maintaining vigilance around the facility if it is regularly brought to the attention of the public over the course of successive generations. Thus, it is essential to **establish mechanisms, or systems, that encourage the development of an active memory of the facility and its registration in the various records kept by the community as the years pass** (regularly updated archives, registration in land registers, etc.).

One factor in keeping the active memory alive is to **sustain economic and social life in the vicinity of the waste facility** since stable local and regional demographics plays a key role in ensuring sustained monitoring. To this end, **the task of monitoring the facility should be integrated into a general sustainable social and economic development plan for the area**. For example, the development of business activities related to monitoring and inspecting the environment needs to be examined, interrelated with the development of scientific and technological skills at the local and national level.

It is also necessary to examine **ways in which information is passed down to future generations so that they can understand the memory they have inherited**. This implies ensuring that the information passed down makes sense and is of value to successive generations.

Sustainability of "institutions"

Maintaining vigilance in the long term raises the **issue of how sustainable the institutions in charge of the vigilance processes may be.** Studies have been carried out on the systems designed to prevent, as far as possible, a disposal facility from being abandoned and to ensure that it is taken under control in the event of any failure on the part of local or national "institutions" following, for example, a crisis situation (economic crisis or war, etc.)[34]. These studies reveal a **need to develop the vigilance at different levels, i.e. local, national and even international, and to create a network of actors participating in the surveillance.**

Points of view expressed by some actors regarding keeping the memory alive

Sustaining economic and social life
One of the major concerns expressed by local actors regarding the Bure laboratory lies in maintaining stability in local and regional demographic figures. The areas surrounding the laboratory are not at all densely populated and the population in the "counties" of Meuse and the Haute-Marne is consistently decreasing and ageing. Sustainable social and economic development plans therefore need to be implemented, to encourage young people to remain in these areas.

4.5. Financial aspects

Funding the reversibility
The ability of future generations to maintain a capacity of choice between the options throughout the period of reversibility will mainly depend on the available financial resources. **An adequate financial mechanism should be set up to cover the surveillance and maintenance of the facility keeping the options opened, the packages retrievable and potentially the development of alternative options.**

Given the length of the periods involved, such systems need to include **periodic estimation of the various costs involved, resulting, if necessary, in a re-assessment of the sums set aside.** Taking the long-term view also raises the issue of **maintaining the financing capability** and the possibility of **changes in who bears the financial responsibility** over the years i.e. identify who has to support the different expenses at each stage.

To improve vigilance at local, national and international level, **mechanisms designed to ensure transparency with regard to the financing systems and cost assessments** need to be developed hand-in-hand with, for example, the organisation of regular meetings with the various actors at which these different factors can be presented and discussed.

Financing vigilance undertaken by local actors and expertise

To fulfil their vigilance tasks effectively, **local actors must have adequate financial means** to be able to carry out specific actions related to such vigilance. This mainly means being able**, if necessary, to call on pluralistic expertise** to examine the different issues raised in the course of the decision-making process related to reversibility.

4.6. Citizen competence and expertise

With a view to playing an active role in the decision-making process related to reversibility and fulfilling their task of ensuring vigilance, **it is essential for local actors to have the competence required to be able to express their expectations and concerns on the reversibility process not only concerning technical issues but also concerning governance issues.**

Improving local actors' levels of competence depends on them having access to "training" in the different aspects related to the management of a reversible waste disposal facility, covering the technical and other aspects (ethical, legal and financial, etc.) involved in assessing the management system.

Local actors' competence may also be developed by calling on the expertise of the public authorities as well as other sources of expertise from different types and origins. It is therefore important to provide them with the possibility of calling on pluralistic expertise at all the different stages in the decision-making process related to reversible radioactive waste disposal.

In addition, given the specific timescales related to radioactive waste disposal, it is essential to look into **mechanisms for sustaining such competence over time and for handing it down through future generations.**

Viewpoints of some actors with regard to competence

Improving citizens' competence
In general, the local actors we met in the course of this study spoke of the difficulties they have encountered in trying to gain access to the level of knowledge they require to play an active role in monitoring disposal facilities. While they want to be involved in the monitoring system, they stress the need to maintain other sources of expertise to ensure control over the potential risks related to radioactive waste disposal facilities.

Sustained competence
According to the IRSN, the real challenge involved in reversibility lies in ensuring that knowledge is transmitted over the long-term, i.e. that professional expertise and organisational control over the radioactive waste management system are maintained.

5. CONCLUSION/OUTLOOK

The aim of implementing reversibility in practice is to conserve the possibility of choosing between three main options: continue to maintain reversibility, retrieve packages or initiate the closure of all or part of the disposal facility. Maintaining this choice in the long term implies setting up specific institutional, financial and decision-making systems, etc. that need to be jointly developed in advance by all the actors concerned, be this at local, national and even international level. This study has revealed perspectives for further study in various areas that could be developed by the different actors (institutions, associations, local actors, etc.). In particular, further investigations could be carried out in the following areas:

- Drawing up the decision-making process related to reversibility (steps, participants and criteria, etc.);
- Drawing up the monitoring plan (in terms of technical aspects, safety, impact on the environment and on health, etc.) and developing monitoring indicators;
- Defining cost assessment procedures for the different options related to reversibility;
- Drawing up and implementing a sustainable social and economic development plan at the local level;
- Improving the level of competence of actors from civil society;
- Passing skills and expertise down to future generations;
- Keeping alive an active memory of the facility;
- etc.

While these studies have mainly been based on the situation in France, they identify certain issues that are of concern much more widely to any radioactive waste management system that incorporates a period of reversibility. Thus, within the framework of the CIP project, it may be noted that the English group of actors examined the issue of the practical implementation of reversibility, even though no decision has yet been taken as to the waste disposal concept to be implemented in the UK. In particular, the group highlighted the need to be able to discuss the issue at the European level.

APPENDIX 1. THE ENGLISH VIEW

The English have a specific point of view as regards reversibility [32-33] in that they distinguish between three types of package retrievability. We shall define these to clarify the vision they have of the decision-making process related to radioactive waste management.

- "Reversibility": Radioactive waste can be removed from a disposal facility simply by reversing the initial emplacement process. In this case, the disposal facility has not been backfilled or sealed.
- "Retrievability": This assumes that additional steps must be taken to retrieve the waste. If the access drifts have been left open, this may entail removing the backfill from the roof.
- "Recoverability": This assumes that the radioactive waste can be retrieved using mine working techniques or other similar techniques. In this case, the entire disposal facility is backfilled and sealed.

It is generally understood by the majority of stakeholders that the need for "retrievability" to which they refer is really closer to the term "reversibility" than to "recoverability".
Prior to the process undertaken by the Committee on Radioactive Waste Management (CoRWM), Nirex developed two concepts of staged geological waste disposal that would allow for reversibility covering a period of a few hundred years before going ahead with any backfill or sealing operations.

- The first concept entails keeping the facility open for the entire period, the vault could remain open, maintenance and backfill could be implemented and the atmospheric conditions in the disposal facility could be checked at regular intervals to preserve the integrity of the packages for as long as possible.

- The second entails a facility that would be backfilled and sealed as soon as the last package has been emplaced. This would be the cheapest option.

The Environment Agency expressed its doubts as to the viability of the first concept presented by Nirex, which it believes would not technically be reliable enough, as well its concern over the possible degradation of the packages during the period of reversibility.

For its part, Nirex maintained that if the packages are stored under good conditions and are handled correctly, they should not need to be repackaged for a period of 300 years.

At the same time, the British authorities do not appear to be in any hurry to make a final decision as to integrating reversibility in disposal facility design. With regard to the issue of the preparation and planning for the implementation of geological disposal, according to the White Paper presented to the British Parliament in June 2008 by the

Secretary of State for the Environment, Food and Rural Affairs, the Government's view is that the decision to keep the disposal facility "open" for a prolonged period of time can be taken at a later date, in consultation with independent regulators and local communities. In the meantime, the site may be planned, designed and constructed in such a way as not to exclude the option of retrievability.

The right of withdrawal: For the British government, the right of withdrawal is an important part of the voluntarism approach intended to develop and maintain public confidence. It will thus be possible for a local community to decide to withdraw even at an advanced stage of the process, right up to the moment when underground operations and construction are due to begin.

Engagement packages: Communities that have taken a decision to participate will incur costs. The Government will assist communities in either partly or wholly meeting these costs through the provision of an "Engagement Package". The level, coverage and the point at which funding is available will be considered as part of the initial discussions between the community and the Government.

Benefits packages: "Construction and operation of a geological disposal facility will be a multi-billion pound project that will provide skilled employment for hundreds of people over many decades. It will contribute greatly to the local economy and wider socio-economic framework. There could be spin-off industry, infrastructure, local education or academic benefits, together and positive impacts on local service industries that support for the facility and its workforce. It is also likely to involve major investments in local transport facilities and other infrastructure, which would remain after the facility has been closed. In addition there may be other benefits which may be commensurate with developing the social and economic wellbeing of a community that has decided to fulfil such an essential service to the nation."[9]
The implications of this option on radioactive waste containment and packaging will be kept under review.

Case study presentation by Mr. Richardson on taking reversibility into account in the United Kingdom (meeting of the French group, December 2007)

The United Kingdom's policy on radioactive waste management has also undergone a number of changes. Thus, in 1997, a proposed disposal facility for intermediate level waste (B waste) was refused for the Sellafield site. In 1999, a public debate was held on the issue of waste disposal. This debate revealed strong demand for retrievability on the part of civil society. In 2002, Managing Radioactive Waste Safely (MRWS) process for high level waste (B and C waste, not including fuel) was launched. The Committee on Radioactive Waste Management (CoRWM) was set up in 2003 to identify a waste management option that would be both technically acceptable and acceptable to the public. This committee was set up on the basis of broad consultation with the public and the scientific community.

9

The Committee's proceedings resulted in adopting the following ethical principles:

- Inter-generational equity (avoid undue burden), a burden supported by the present generation or leave the burden for future generations to deal with.
- Intra-generational equity (impartiality)
- Sustainability

The Committee undertook a number of broad public consultations, including many national and local meetings, broadcast panel discussions and restricted group consultations for same stakeholders, etc.

These various consultations have furnished the following information:

- Many people support an approach whereby the burden on future generations is reduced but which nonetheless offers flexibility to take certain measures if necessary.
- Retrievability was viewed as a response to such desires, although there was confusion over the precise definition of the term (compared with reversibility and "recoverability").
- It is possible that for some people, retrievability appeared to signify a lack of confidence with regard to the concept of disposal.

Identification and analysis of the alternatives proposed by the CoRWM:
Site selection:

- Storage: above-ground; below-ground; protected or unprotected
- Disposal (near-surface; ice sheets; deep boreholes; space; geological etc)

Preselection (November 2005):

- Storage
- Geological disposal
- Phased geological disposal
- Near surface disposal for short-lived wastes (B waste).

There are four variants of the two geological disposal alternatives, three of which incorporate reversibility:

1. Emplace waste and seal it immediately
2. Only seal the first vault, leaving the others open (thereby enabling management of the latter)
3. Emplace the waste and leave all the vaults/tunnels open until the last package is emplaced.
4. Emplace the packages and leave the facility open for at least a hundred years

To decide which option to implement, a multicriteria analysis was carried out.
These criteria included technical, social, economic and environmental aspects.

In July 2006, CoRWM recommended:

1. Giving priority to robust interim storage that would meet safety requirements relative to the risk of terrorism
2. Geological disposal (with variants 1, 2 or 3, depending on the public's decision)

According to CoRWM, variant 4, which leaves the facility completely open for at least a hundred years, would increase the risk disproportionately to the intended benefits.

Government consultations held from July to November 2007 led to the following points:

- Strong support for CoRWM's proposals (with certain reservations regarding organisational aspects)
- The recommendation to close the facility permanently as soon as possible, with a view to ensuring safety, to avert any terrorist risk and minimise the burden on future generations in terms of cost, maintenance and doses received by workers.
- The recommendation to nonetheless leave open a possibility for future generations to decide whether or not to retrieve the waste by designing a disposal facility that does not exclude the possibility of being re-opened.
- Consultations should be held between the operator and the local host community to initiate discussion of facility design.

The Government published a White Paper in June 2008. It states that:
« 4.20. Government acknowledges that there is a divergence of views on the issue of waste retrievability, but on balance considers that CoRWM's conclusion was correct, i.e. that "leaving a facility open, for centuries after waste has been emplaced, increases the risks disproportionately to any gains" (Ref. 1). Closure at the earliest opportunity once facility waste operations cease provides greater safety, greater security from terrorist attack, and minimises the burdens of cost, effort and worker radiation dose transferred to future generations.
4.21 CoRWM noted that it is likely to be at least a century from publication of their recommendations in July 2006 until final closure of an entire facility is possible Ref. 1). In practice it could be longer. This timescale provides sufficient flexibility for further research to be undertaken. »

To summarise the British view of reversibility, we find:

- A major need to clarify the definitions of retrievability and reversibility
- A need to review the design of the disposal facility so that it will not exclude the possibility of reversibility
- General acceptance for the idea of integrating retrievability in facility design to potentially afford the benefit of choice to future generations without placing an undue burden on the present generation (increased doses to workers and dangerous facilities, etc.)
- A general demand to instigate discussions with local host communities.

APPENDIX 2. RECAP OF THE FINANCIAL CONTEXT RELATIVE TO RADIOACTIVE WASTE MANAGEMENT IN FRANCE

(Position of DGEC[10], Ministry of Ecology, Energy, Sustainable development and Sea)
Two funds managed by ANDRA

The Act of 28 June 2006 included provision for two research funds to be set up for the HLW-LL disposal facility, to be managed by ANDRA to:

- Fund research and studies on interim storage and deep geological disposal of radioactive waste. This fund can be used to fund research on reversibility as part of research on radioactive waste disposal and is funded thanks to the additional research tax. This fund already exists. The rate of this tax is set each year by the Directorate-General for Energy and Climate (DGEC) following consultation with ANDRA to estimate its financing requirements and those of the industry (AREVA, EDF and the CEA) which pays this tax to the State. The ASN may also be consulted on whether or not it finds the evaluation of these provisions credible.

- Funding for the construction, operating, final closure, maintenance and monitoring of storage and disposal facilities for high- and intermediate-level long-lived radioactive waste built or operated by the agency. *"It seems that it is not possible to use this fund for waste recovery given that the disposal facilities are constructed without any intention of retrieving the waste."* This fund will be sourced by contributions paid in by BNI operators once the permit to construct and operate the geological disposal facility for HLW-LL waste has been granted. This fund, allocated to ANDRA, can only be used for these activities, thus it is a sort of safeguard for the producers.

Waste producers' financial responsibility
Producers of radioactive waste[11] are considered responsible for the waste they produce in light of the "polluter pays" principle set down in Article L-542 of the French Environment Code. Thus, research on waste management solutions carried out by ANDRA will be funded by the producers in proportion to the quantities of radioactive waste they produce. The reasoning behind this future burden is that the industrial producers should set funds aside, factoring in the industrial practice of reprocessing of spent fuel, a scenario regarding the long-term management of ILW-LL and HLW-LL waste, namely underground disposal in deep geological formations and dismantling nuclear power facilities.

[10] Comments made during an interview at the DGEC in July 2008 and at the CIP France meeting in November 2008

[11] The major producers of radioactive waste are EDF, the CEA, and AREVA

Prior to voting on the Act of 28 June 2006, a major debate was held by the government on which organisation should be appointed to develop these funds, i.e. the State (through ANDRA) or the nuclear industry. Thanks to the 2006 Act, these funds will remain in the hands of the industrial producers to ensure effective management and avert any risk of these amounts being used for other priority purposes. A plan for sourcing these funds on a sustained 5-year basis was decided upon for the producers. Nonetheless, in the event of any failure on the part of the producers, it is not impossible that the State may take over responsibility for radioactive waste.

The estimated amount of funds is based on the estimated cost of a geological disposal facility. The last estimate dates back to 2005, factoring in the option of reversibility, and was calculated by a working group that included the DGEC, the Budget Directorate, the Treasury Directorate, ANDRA, EDF, AREVA and the CEA (see the report published on the DGEC website), and was approved by the ASN. The evaluation adopted by the operators is that of the "industrial scenario"[12] (IS), which is between 13.5 billion euros and 16.5 billion euros. These figures are due to be reviewed in 2010 (to include studies in 2009, when ANDRA is expected to have made certain adjustments related to key safety options). The cost of reversibility as such is not defined in the report. This issue is due to be determined in more depth at the next evaluation review.

The potential cost of retrieving packages and the costs related to an alternative reprocessing/disposal solution for retrieved packages have yet to be estimated. This is to be examined by Parliament in 2015.

Table 1. Estimation of geological radioactive waste disposal implementation (in billions euros)

	low IS	**high IS**
Investment (construction, closure, project management, land, transportation, packaging and surface facilities)	3.9 (29%)	4.2 (25%)
Operating (personnel, operating/maintenance, upgrading, pre- and post-operating)	4.4 (33%)	5.4 (33%)
Miscellaneous (Taxes and duties, insurance, detailed design phase, R&D, payroll)	3.2 (24%)	3.6 (22%)
Contingencies	0.2 (1%)	0.6 (4%)
Risks and opportunities	1.8 (13%)	2.7 (16%)
Total	**13.5**[13]	**16.5**

[12] Main scenario assumptions: (i) the industrial scenario assumes that all spent fuel is reprocessed and is based on a given inventory and time chart; (2) concepts without engineered barrier for C waste and with stackable B waste packages; (iii) reversible disposal with closure after emplacement of the last scheduled waste package in the disposal facility.

[13] These estimates include costs related to operating the disposal facility and to dismantling

APPENDIX 3 THE CLIS' OPINION

THE CLIS' OPINION ON EXTENDING AUTHORISATION TO CARRY OUT RESEARCH AT THE BURE UNDERGROUND LABORATORY (adopted at the Plenary Session of 12/10/2006)

While critical of the fact that there is currently only one underground laboratory, the Local Liaison and Monitoring Committee (CLIS) notes that the Act of 28/06/06 relative to sustainable management of radioactive materials and waste stipulates that research must be carried out at the Bure laboratory to achieve the objectives of the programme defined in the Specifications appended to the Decree of 03/08/99 authorising ANDRA to develop and operate the laboratory.

Consequently, the CLIS wants to see particular attention paid to the study of the conditions for reversibility (defining the length of the period of reversibility, which should begin on the date the future disposal facility stops operating and not the date that authorisation is granted, facility monitoring methods and techniques during operating and after it has been closed), together with a demonstration of the absence of specific or exceptional geothermic resources in the region of Bure.

It asks that the conditions for study in the laboratory should be as similar as possible to those expected in a disposal situation, especially insofar as their concern analysis of the interaction between various parameters (heat/radiation, for example) or the behaviour of the environment and its reactions to excavation, the construction of engineering structures and the presence of packages containing radioactive waste. Full-scale experiments and studies on the long term should be carried out with a view to more reliable modelling and a safety study as close as possible to real conditions.

Lastly, the CLIS expects to be informed in detail and on a regular basis of progress regarding all research carried out by ANDRA at the Bure laboratory and at any other laboratories (including research on radioactive waste conditioning) and of the results achieved.

APPENDIX 4 REVERSIBILITY IN PRACTICE- THE LOCAL ACTORS' POINT OF VIEW

Local actors' proposals

Cowam In Practice
French National Stakeholder Group (NSG)

Chantal Rigal,
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The exchanges and discussions on reversibility developed by the pluralistic group *Cowam In Practice France* have helped to build a common understanding of issues and questions associated with this concept. The ANCLI requested CIP to expand the contribution of local actors and to organize two regional meetings in May-June 2008 (Bar-le-Duc, Flottemanville-Hague) and an inter-regional meeting in September 2008. These sessions have enriched the reflection of the French group providing feedback on two elements: the reflections of CLIS in terms of reversibility, the feedback of the operation of the CSM. On this basis, the territories of the Hague and Meuse Haute-Marne have also identified a number of proposals.

The reversibility is included in the 2006 Law on the sustainable management of radioactive materials and waste as follows: "The disposal of radioactive waste deep underground is the disposal of these substances in a facility specially equipped for this purpose, in compliance the principle of reversibility."(Article 5); "The Government presents a bill establishing the conditions for reversibility. After enactment of this law, permission to establish the center may be issued by government decree passed in the Council of State, after public inquiry. (...) The authorization sets the minimum period during which, as a precaution, the reversibility of disposal must be ensured. This period may not be less than a hundred years." (Article 12)
Local actors are doubly concerned by reversibility.

- *By their statutory mission, Local Commissions and Committees have a role of vigilance and will be able to look after reversibility, i.e. maintaining a capacity of choice between:*
1. continuation of a reversible disposal,
2. withdrawal of packages and
3. closure of disposal.
This monitoring concerns as much technical aspects, as the legal, financial and decision-making dimensions associated with reversibility.

- *On the other hand, the local actors raised the question of preparing the governance of reversibility within the 5 to the 8 coming years. What procedure to prepare this device? What contribution of citizens? How will this be taken into account in the decisions?*

In its recent opinion on the radio-ecological monitoring of water around the nuclear plants and on the management of older storage sites for radioactive waste (6 November 2007 opinion, www.hctisn.fr), the High Committee for Transparency and Information on Nuclear Safety (HCTISN) stressed the essential role of CLI in the continuous improvement of the nuclear sites management.

1. The obligation of reversibility: an opportunity to monitor and improve

For local actors, reversibility introduces an essential time frame to **maintain a capacity of choice** between three management options (continuation of reversibility, packages withdrawal, closure of disposal) and **influence the adjustment** of the management system **during time**.

To build a **practical reversibility,** locally operational, actors from local communities believe it is now important to negotiate **governance processes where local players have their place**.

The reversible disposal is made in a first time to **monitor and verify** what is put on the site - the **inventory** should be shared and discussed with local actors, and provide reliability and confidence guarantees necessary to these actors.

Reversibility is also an opportunity to **ensure that security is maintained**. More generally, it is possible to **determine the viability** of waste management options, to **question** and **improve them over time**. These questionings are related to the various pillars of reversibility: environmental and health monitoring, funding, accountability, local monitoring...

Reversibility only makes sense if accompanied by **oversight, feedback and evaluation** to be able to make an informed choice among the three management options. Through this monitoring work, the civil society will **develop**, and **maintain a critical and cautious look at the selected options,** in order **to take into account the ethical concerns of local communities** in the decision-making process. The local actors contribute to organise the return of experience in this perspective.

2. The preparation of reversibility

Local actors want the period by 2015 to be an opportunity to prepare reversibility. They want to focus as much on the technical aspects as on the governance framework that will support reversibility and translate this concept into a practical reality, able to provide technically, legally and financially a sustained capacity of choice.

In this perspective, local actors can offer their own vision of practical reversibility, and contribute to the reflections conducted by the various actors responsible for the development of concepts (technical and others) of reversibility.

A major concern is to ensure that the technical device is in line with the governance framework of reversibility. This requires a continuous dialogue between the different actors responsible for the practical implementation of reversibility now, without waiting for 2015.

Local actors involved in the CIP French NSG led a return of experience, on the one hand on the reflections of CLIS in terms of reversibility, and on the other hand on the CSM (Centre de Stockage de la Manche). The operation of this facility covers a period of 40 years. It is subject to constant monitoring by the operator, and the safety authority.

A thorough evaluation was carried out in 1996 with the Commission Turpin. In addition, local associations such as ACRO keep a close watch on the center and carry out their own measures. This monitoring highlights a number of issues concerning the long time that are particularly relevant to a generic reflection on reversibility (construction and memory of the inventory, environmental monitoring and oversight of the facility...). For Commissions and Local Committees, such returns of experiences are very useful tools to better understand the issues and practical conditions of reversibility. Sharing other cases on relevant experiences of success or difficulties is considered. We particularly consider cases such as the Dutch or German ones (Habog, Ässe ...).

The ANCLI wishes to facilitate exchanges and return of experience between regions involved in waste management in France and more widely in Europe. The exchange between these territories should enable local players to learn from each other about their concerns and establish their views and contribution. It must be continued with a dialogue with other stakeholders: operators, and other national institutional actors, to investigate the various aspects of waste governance:

- The decision-making process until the end of the reversibility period
- The waste inventory
- The monitoring programme
- The assessment of costs and monitoring of the fund management
- Memory and intergenerational transmission

The analysis and suggestions of local commissions and committees are set on each of these aspects in the following sections.

3. Decision-making process until the end of the reversibility period

In its 12 October 2006 opinion, the CLIS of Bure hoped that a special attention would be paid to study the conditions of reversibility, and clarified that the starting point should be the date for a possible operation disposal and not the date of its authorization. This view was confirmed in the inter-regional and local meetings organized by CIP.

The implementation of reversibility involves regular meeting points between different stakeholders, including civil society, at local and national levels. These meeting points must verify that the ability to choose between three options (continuation of reversibility, withdrawal of packages, closure of disposal) is maintained in practice, i.e. that we are able both on technical, financial or legal aspect to make a choice as far as possible unconstrained between these options.

Local Commissions and Committees wish they could take an active part in monitoring this system of governance. They will ensure that legal, financial and technical resources are sustained and updated on a regular basis to maintain a genuine capacity for choice. They will also participate in the discussion when a choice between three options will be on the agenda.

Expertise, support to the decision

In this context, Local Commissions and Committees stress the importance of access to expertise and training. Citizens must have access to the data produced by operators and government experts. Other forms of expertise must be mobilized to investigate issues raised by reversibility. Local Commissions and Committees may conduct counter-expertise or complementary expertise. Pluralistic expertises will be made on issues marked by differences or strong uncertainties.

As the stakes of reversibility are not only technical, expertise will cover a broad range of skills (legal, ethical, financial ...).

The role of Local Commissions and Committees over the medium-long term

Local Commissions and Committees want to reflect on their role in monitoring reversibility in the mid and long term. The Commission Turpin had already stressed the role of Local Committees, on waste management, should be strengthened because of long-term facilities considered. *"The Commission should not only be informed, but also give its opinion (...). It does not remove the administrative authorities of their responsibilities. Ultimately, they are or not to accept the proposals of ANDRA. This is forcing a dialogue. Indeed, we are in a very illustrative case. The presence of waste means the presence of pollution, and therefore, not so much a threat than a constraint that people will assume for a very long period. The authorities must take into account the opinion of this committee. They may not follow, but will have to explain."* How can Local Commissions and Committees monitor the implementation of reversibility, from one generation to another? What devices and points of engagement will ensure the inclusion of their opinions?

What organization for the local territory on risk and development issues?

The feedback made between players of the Meuse Haute-Marne and North Cotentin regions highlighted the fragility of citizen participation on the issue of waste. More than on any other subject, the fact to have a vigilant citizen oversight is often perceived as an attitude of distrust against any waste management project. On the contrary, attention to development projects that go with the establishment of a site is analyzed as a sign of overconfidence. These shortcuts, and the divorce between a rationale of development and a rationale of vigilance are counter-productive, and weaken further the participation of local citizens who should be able to legitimately contribute to the reflections on the future of their territory, and look at all aspects associated with a facility sitting. Local Commissions and Committees propose to carry out a reflection on the conditions for successful involvement of the local communities combining development and a capacity of vigilance.

4. Control instruments and inventory oversight

What guarantees and sustainability does the inventory provide? A clear distinction between the responsibilities of waste producers, the operator of the management site and the safety authority enhances the quality of the inventory. The history of CSM has demonstrated the importance for the inventory to be declared and controlled by different bodies. The inventory gains in reliability and transparency.

Since waste will be on their territory for a long term period, it is necessary for local actors to know what goes into the disposal.

The involvement of local actors in the inventory control and monitoring does not replace the responsibility of the producer, operator and safety authorities, established by the two laws of June 2006 on transparency and nuclear safety, and on the sustainable management of radioactive materials and waste.

This oversight will strengthen the sustainability of the memory on the site and what it contains, and the confidence that local players can have in the technical devices used to manage the waste.

5. Site monitoring program : the environment and health

In the framework of the French NSG, members of Local Commissions and Committees have shared an understanding of goals and challenges of a surveillance program of a waste management facility, in the perspective of reversibility.

This monitoring involves both the environment and health impact, and the site itself, to maintain a capacity of reversibility.

Local Commissions and Committees should be able to contribute to the *definition* of the monitoring program. They may give an opinion on the institutional experts' proposals, and may make additional proposals from the local actors' viewpoint, if they deem it necessary.

Local Commissions and Committees will follow the *implementation* of monitoring plans. Scheduled meeting points will have to be organized so they can verify that surveillance is adequately ensured, and propose adjustments if necessary. Local Commissions and Committees will also monitor and evaluate corrective actions, set up after the detection of a problem.

Commissions and Local Committees' oversight is complementary to internal controls, conducted by the operator, and institutional external control (safety authorities, external audit). It is conducted for the territory, with local actors, with the direct objective to answer their questions.

On the monitoring of the site and the environment, as on the control and monitoring of

the inventory, it is interesting to note the recent recommendation of the High Committee on Transparency and Information on Nuclear Safety (HCTISN): *The High Committee recommends that operators of older radioactive waste storage facilities regularly present to the Local Commissions (CLI) the inventory of stored substances, the results of their environmental impact monitoring, the measures implemented to reduce their impact and time involved, and that a dialogue between stakeholders is conducted around these sites.*

6. Cost evaluation and monitoring of the fund management

Discussions on reversibility in CIP have highlighted the difficulty to estimate the costs of waste management. It is indeed difficult to assess what is still partly at the level of concepts, particularly as reversibility introduces a dimension of choice, and therefore an unknown part for our generation.

The 2006 Law provides a structure for financing research, construction, and storage and disposal operations. It strengthens the transparency of resources dedicated to waste management. However, these funds do not cover the potential withdrawal. This lack of specific funding for the withdrawal weakens the credibility of the reversibility concept.

Despite - or because of - the unknowns that surround the waste management method, it is therefore necessary to consider now the evaluation of future costs: disposal solutions costs, reversibility costs, particularly cost of the withdrawal, management provisions, etc…

How to keep over time a fund away from financial uncertainties? Once the budget for waste management is defined, it is necessary to ensure that resources are well managed, maintained and adapted to circumstances if new needs are there. Thus, Local Commissions and Committees would also join in discussions on the mechanisms of monitoring that will ensure the adequacy, the good supply and good management of these funds. They will ensure that funding arrangements will guarantee a capacity of choice between three options constituent of reversibility (continuation of a reversible disposal, withdrawal of packages, closure of the disposal).

In any event, the cost associated to the disposal and its reversibility should not ultimately invalidate any alternatives options, neither fall on the hosting communities' charge.

7. Memory and intergenerational transmission

The preservation of memory around the disposal site is essential. Many reflections are conducted to promote a transfer of memory on a passive way to overcome a possible period of oblivion. In a prospect of reversibility, the local actors insist on the need for active memory, only capable of maintaining a capacity of control and choice from one generation to another: how to give meaning to information and memory so that future generations are involved in risk management? How to pass from the information to the value?

One factor to keep a memory around the site is the existence of a social life. Can economic life be a factor to enhance memory and vigilance of the area? As mentioned above, there is a risk of polarization in the communities between actors whose vision is only focused on risks, and actors who are only concerned with community development. A reflection must be undertaken on how to integrate development and vigilance in order to promote local dynamics able to sustain a vigilant oversight.

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