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Reversibility of Decisions and Retrievability of Radioactive Waste: An Overview of Regulatory Positions and Issues

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The mission of the NEA is:

– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;

– to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information.

The NEA Data Bank provides nuclear data and computer program services for participating countries. In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

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Reversibility of Decisions and Retrievability of Radioactive Waste: An Overview of Regulatory Positions and Issues[1]

1. Introduction

At one time disposal was often treated as if it were a relatively short-lived activity to be completed in the timespan of perhaps a single generation – the goal being to provide a facility that could safely contain radioactive waste without any further action or intervention by future generations. Increasingly, the implementation of a disposal project has come to be viewed as an incremental process, in a series of successive steps, likely taking several decades to complete. Besides the already well-established concept of protection of future generations, this changing vision incorporates the desire to preserve as much as practicable the ability of succeeding generations to exercise choice, in case they want to do so. Reversibility and retrievability have also brought up as topics and potential goals for during both pre- and post-closure of deep geological repositories in order to preserve choices. As part of this evolution, public stakeholders request to be better involved in decision making especially concerning monitoring and surveillance. Both activities are now under consideration after closure of the facility (NEA 2014).

The Radioactive Waste Management Committee (RWMC) of the NEA has been at the forefront worldwide in examining the topic of Reversibility and Retrievability (R&R). As early as 2001, an NEA survey-based report entitled "Reversibility and Retrievability in Geological Disposal of Radioactive Waste" provided an overview of R&R by an ad-hoc group of experts from 11 NEA Member countries.

The 2001 report (NEA 2001) observed that national safety regulations dealt mainly with operational safety and design targets for long-term (post-closure) safety and relatively little consideration was given to retrievability/reversibility or its implications. Yet, policy frames saw benefits from retrievability. It was acknowledged in the report that it is important that regulatory requirements be reviewed to check that they reflect the aspects of maintaining security and safety, including radiological protection and nuclear safeguards, both during possibly prolonged open periods and over the long term. In the context of a stepwise licensing process the operator may propose, at each stage, retrieval as a fall back solution.

In 2007, the RWMC launched the NEA R&R project[2] with participation from 15 countries and two international organisations. The project included, amongst its members, representatives of six organisations involved in regulation, five regulatory authorities of five countries and one technical support organisation to the safety authorities: Federal Agency for Nuclear Control (FANC, Belgium), Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMU, Germany) and Gesellschaft für Anlagen- und Reaktorsicherheit (GRS, Germany), Nuclear Safety Council (CSN, Spain), Nuclear Regulatory Commission (NRC, United States) and Environmental Agency (EA, United Kingdom). The project aimed to improve awareness amongst the RWMC constituency of the breadth of issues and positions regarding the concepts of R&R with the goal of providing a neutral overview of relevant issues and viewpoints in OECD countries. Hence substantial attention was given to R&R regulatory issues mainly in the context of decision making for repository development. The report (NEA 2011) points out regulatory issues, including safety criteria and licensing considerations.

1. This document was compiled for the RWMC Regulators' Forum by Carmen Ruiz-Lopez and Claudio Pescatore.
2. www.nea.fr/rwm/rr/.

In the framework of this above mentioned NEA R&R project an international conference was organised in Reims,[3] in December 2010, where a specific panel on “The place of R&R in regulatory policy” was included. The conference includes presentations on regulatory and regulatory policy aspects. Namely from Belgium (W. Blommaert, FANC), France (M. P. Comets, French Nuclear Safety Authority (ASN)), Finland (R. Paltemaa, Radiation and Safety Authority (STUK)), Germany (G. Arens, BMU), Japan (S. Shiroya, Nuclear Safety Commission (NSC)), United States (D. Shultheisz, Environmental Protection Agency (EPA) and C. Haney, NRC), Sweden (A. Gerhardsson, Swedish Radiation Safety Authority (SSM)), Switzerland (P. Hufschmied, Swiss Federal Nuclear Safety Inspectorate (ENSI)). These presentations are recorded in the conference proceedings (NEA 2012a).

The conference report summaries most of the relevant observations acknowledging among other aspects that reversibility of decisions and retrievability of waste are complex subjects that cannot be considered in isolation from safety and societal issues.

Finally, a brochure was elaborated and published (NEA 2012b) collecting the most relevant R&R technical considerations and observations for national geological disposal programs, including among them some regulatory issues.

The present document presents an overview of findings, positions, boundary conditions and issues based on the results of the R&R project of 2007-2011 and of the Reims conference of December 2010. Intention is to collect in one document reference information on the topic of R&R from a regulatory viewpoint. To help the reader an appendix provides the list of acronyms used in this text.

2. Observations from the R&R Project

Observations from the R&R project (NEA 2011) are offered hereafter, focusing on decision making and the regulators’ role.

2.1. Stepwise decision making and reversibility

In its various forms (adaptive phased management, adaptive staged management, phased geological disposal, reversible disposal, …), stepwise decision making in geological disposal represents an approach to making a gradual transition over one or more generations, from active assurance of safety (interim storage) to passive safety (final disposal with no requirement to retrieve the waste). As part of a stepwise decision-making process, it may be considered that the possibility should exist to reverse or revise previous individual decisions along the way, for example in the light of knowledge gained or of changing capabilities. Thus, stepwise decision making may bring with it a need for some degree of reversibility, including retrievability, at least up to the point of final closure if not beyond. Stepwise decision making forms an important part of the context for a study of reversibility and its expressions in retrievability provisions.

For *stepwise regulatory and policy strategies to be credible*, they must be reversible or at least modifiable in the light of new information, to the extent that this is practicable. The reversibility within a planned process should probably be discussed ahead of time. Whether foreseen or not, modification of any given decision always exists as a contingent possibility, even when the decision maker’s intention is clearly to eliminate all but the selected option. The question is whether to incorporate planning for this contingency within a defined decision-making process.

2.2. Regulatory authorisations and R&R

Reversibility refers to the possibility of reconsideration of one or a series of steps at various stages of a program. This involves a review of earlier decisions with the appropriate stakeholders and requires that the

3. www.nea.fr/rwm/rr/reims2010/index.html.

necessary means to reverse a step be available. Reversibility also denotes that, when practical, fall back positions may be incorporated both in the long-term waste management policy and in the actual technical program. Not all steps or decisions, however, need be or, indeed, can be fully reversible. Certain steps can be used in the process as hold points for programme review and confirmation. Reversibility may therefore be considered to be a way to close down options in a considered manner, while still respecting the need to take decisions in a timely fashion. If the need to reverse or change course is carefully evaluated with appropriate stakeholders at each successive stage of development of a facility, a higher level of confidence may be achieved, by the time a final closure decision is to be taken, that there are no technical or social reasons to delay the final decision, or to undertake waste retrieval at that time or subsequently. However, in order to embark successfully on a logic of reversibility in waste disposal, it is important to ensure that the need to consider decisions at each step is not used as an excuse for unnecessarily delaying the process. It is also advisable to clarify the reference principles or values that should be followed in such decision making steps, and their importance relative to one another.

There are formal licensing actions before the initiation of major steps such as siting, construction, operation, and closure, but not necessarily at various other points such as partial emplacements in new disposal areas, backfilling, etc. The basis for the regulatory process is not necessarily the same as for a flexible stepwise decision-making process. The steps considered in typical licensing processes are very broad, and may limit the evolutions that are possible during implementation. For example, a proposal to dispose of a small fraction of the wastes and wait for several decades before proceeding with the rest of the wastes may not fit within the normal series of licensing decisions; also construction of new parts of the facility and operation in constructed parts are likely to occur during the same periods of time. On the other hand, it must be recognised that there is more to regulatory activities than licensing, and that the day-to-day regulatory oversight process can be compatible with a flexible process involving many small steps.

Nevertheless, these actions may be considered to be key points that would be submitted in any case to regulatory review, either through the terms and conditions of the authorisation or being considered as “significant modifications”, requiring a licensing decision. If as a consequence of stepwise decision making there is a significant change, *e.g.* backfilling that makes retrieval more difficult, the regulator would need to be involved, *i.e.* a staged process would also involve staged authorisations even if the licensing process was not explicitly staged. For example, in the US any condition that would substantially affect the retrievability of waste prior to closure would require a licence amendment.

Prior to closure, for operational safety, the regulator may demand that there always be a safe position to return to in case of problems. For practical purposes, this would imply that retrievability of packages be a requirement during the emplacement phase. As for the post-closure phase, the internationally accepted safety principles require that the safety of a final repository must not rely on societal control, including retrievability. Therefore although it is expected that regulators may require retrievability pre-closure; they may not do so during post-closure unless retrievability is imposed by law. On the other hand, even if closure is approved, the logic of preserving future choice as much as possible, suggests that the design should not make retrieval unnecessarily difficult.

One point of interest relates to delayed closure. If decision making and retrievability requirements lead to a delay in sealing or backfilling galleries, there may be an impact on safety. Therefore the regulator needs to be involved in any such decisions, preferably from an early stage when such delays may be considered or planned as part of the development process (*e.g.* in a “flexible” or “adaptive” staged process).

At each step in the entire decision-making process, a decision to proceed also implies a reaffirmation of previous decisions. In a decision-making process which is reversible, this reaffirmation may be made explicit to a greater or lesser extent. That is, a decision to proceed, taken in the framework of a reversible process, also involves in effect a decision not to reverse one or more previous steps. For example, a regulatory licensing decision typically involves a review of compliance with the conditions of the previous licence, and only after it is concluded that the previous conditions have been satisfied will a decision be taken on moving forward with the next steps. It has also been pointed out that for the licensing decision at this stage to be meaningful, there must be at least a possibility that the decision will not be to go forward, but rather to step back and correct shortcomings encountered during the previous phase. Thus a decision not to reverse, whether taken implicitly or explicitly, has the effect of reaffirming previous decisions, and the recording of these decisions and reaffirmations at each step serves to legitimise and facilitate subsequent decisions, including the final decision on closure if and when that decision point is reached.

2.3. Decision making for retrieval

Decision making on retrieval would likely be a complex process if the containers are already in sealed vaults or galleries and if the number of containers to retrieve is important. The example of the Asse site in Germany shows that a variety of criteria would need to be considered, relating to topics such as operational safety, environmental consequences, long-term safety, feasibility, cost, time requirements, the requirement for new interim storage and management facilities and possibly for a new repository for wastes generated during retrieval and processing of retrieved materials, and transportation of waste materials. It is likely that some form of weighting of criteria would be needed, and this weighting is likely to depend upon standards and attitudes to safety prevalent at the time of retrieval, which of course cannot be predicted at the time of emplacement of the materials.

It is generally agreed that, after closure, retrieval would be a new nuclear operation requiring a new licence. One question that may need to be resolved, after closure, in some countries is ownership of the material. A related issue is the possible distinction between physical closure (sealing of the last access shaft) and regulatory closure, which may be some time later in order to accommodate a post-closure surveillance period during which the operator may continue to be responsible. If the time period foreseen for such a surveillance period is very long, it may be necessary to have some method to transfer responsibility to another entity, since the organisation originally responsible for the production of the waste may not continue to exist, especially beyond the end of nuclear energy production in a country.

Even if retrievability following closure is a national requirement or policy, retrieval will not be decided and undertaken lightly. The ability to take retrieval steps, although not forming part of the long-term safety case, may nevertheless prove valuable in as a contingency. A regulatory approval to remove wastes would require that facilities exist to accept and manage the retrieved wastes safely.

If retrievability is a pre-requisite in the disposal programme, the repository licence may include retrievability conditions that may apply during specified periods of time, e.g. during the emplacement phase, or prior to closure. Retrieval of a small number of individual packages for operational reasons during the emplacement phase is often considered to be part of operating practice, and would be funded as part of the basic programme. Retrieval of a part or the whole of the inventory for other reasons is generally treated as a new activity, requiring a new licence, and that would be funded only at the time it was decided upon.

There exist means to enhance the potential for waste retrieval, e.g. by implementing more durable containers and waste forms, or by stipulating longer periods for observation before emplacing backfill materials or sealing galleries or the whole repository. There is, however, a delicate balance to consider, i.e. whether enhancing retrievability may or may not jeopardise safety and/or the continued ability to ensure physical protection of nuclear materials, both for present and for future situations. On the other hand, a better access to the waste can be seen as providing further assurance of reaching a final safe configuration, in that, during the operational phase, intervention to correct problems is possible and, in the post-operational phase, waste can be more safely attained should the need arise or if it were decided to regain access to the waste for reasons other than safety.

3. Observations from Reims conference

At the Reims conference the following general questions regarding regulatory aspects in relation with R&R were raised:

- Are there any challenges to the regulatory framework?
- What kind of implications for monitoring, institutional control and memory keeping? Over what time scales?
- What kind of organisational structure does reversibility imply?
- Are the current regulatory (safety) requirements predisposed in one way or the other, i.e. do they bias the discussion?
- Are regulators' views similar to society's ones, or to implementers' ones, or distinct from both?

Specific regulatory open questions were also raised, including:

- How a future decision to retrieve would be taken?
- How safety and security would be assured at that time?

It was pointed out as well that unforeseen reversals can take place in any programme, and an important question to consider would be whether such reversals should take place within a predefined process or not. For some regulators, communication with stakeholders is an important part of the process, and more work is needed in this area.

The observations from the regulatory presentations are collected under the following rubrics:

- terminology and definitions;
- legal and policy context:
- motivations for R&R;
- practical aspects;
- stakeholder confidence.

3.1. Terminology and Definitions

Definitions and terms are essential for communicating the meaning of words. Generally:

- ***Reversibility*** means the *ability* to reconsider and reverse the course during the development and implementation of a disposal facility.
- ***Retrievability*** refers to the *ability* to retrieve waste after it has been placed.

There are, however, differences, among countries, in the use of terms and in the application of the underlying concepts during the different repository development and implementation steps. Accordingly, there are also differences across regulatory agencies and regulations. Box 1a reports the definitions that could be extracted from the regulatory presentations at the Reims conference.

Box 1a: Definitions of R&R of terms across regulatory agencies

France (ASN)
Reversibility: process of questioning, at each step of the disposal implementation and operation, the decisions taken in the previous steps and of allowing for revision or readjustment of earlier decisions made.
Retrievability: the possibility to retrieve safely waste packages.
Japan
Reversibility denotes the possibility of reversing one or a series of steps in repository planning or development at any stage of the programme: "*Reversibility (reversal of decisions once made after re-evaluation) can be justified only when new evidence emerges which contradicts previous knowledge in terms of ensuring safety*".
Retrievability denotes the possibility of reversing the action of waste emplacement.
NSC and the Nuclear and Industrial Safety Agency (NISA) require retrievability until the time of repository closure when the long-term safety is confirmed by safety assessment taking into account additional information obtained through repository construction and operation.

Box 1a: Definitions of R&R of terms across regulatory agencies *(Con't)*

Germany

Recovery: is the retrieval of radioactive waste from a final repository as an *emergency measure.*

Retrievability: is the *planned technical option* for removing emplaced radioactive waste containers from the repository facility.

United States

Reversibility means the ability to modify, change or reverse a decision and proceed along a different course of action.

Retrievability means the ability to remove high-level waste after it has been emplaced in a geologic repository; this typically implies permanent removal.

Reversibility is a consideration *prior to waste emplacement*. The U.S. program formally considered reversing course during two repository development stages: selection of sites for characterisation (1986-87); and Site recommendation (2002) [Before construction (2009-2011)].

Switzerland

"Retrieval": removal, recovery and transport of emplaced waste from a geological repository to surface.

In some countries, additional terms are used depending of the repository steps under consideration (or linked to the timeframes). A clear example is the case of Belgium. See Box 1b.

Box 1b: Definitions of key terms by FANC. See also Figure 1

Belgium: **Flexibility, Reversibility, Retrievability and Recoverability**

Flexibility*:* The capability and the willingness to re-assess earlier decisions, and the ability to reverse the course of action or decision to a previous stage or to deviate from the reference path. It covers the whole timeline of the development and implementation.

Reversibility, Retrievability and Recoverability*:* Restricted to waste movement operations.

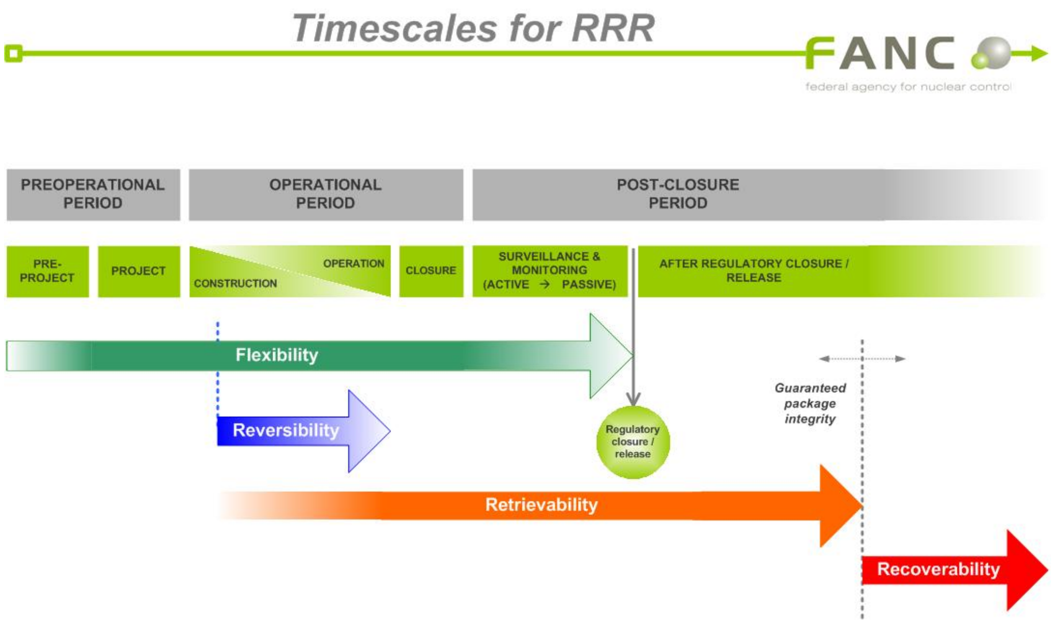
Related to different timeframes/ Depending of the configuration of the disposal package in the disposal area (open, backfilled, sealed...)/ Related to the integrity of the disposal package.

Reversibility: Strictly related to the operational phase. Part of good practice. Feasibility must be demonstrated.

Retrievability: Not a prerequisite may be imposed politically or for public acceptance. Implies integrity of the disposal packages. Up to regulatory closure/release.

Recoverability: The integrity of the package is not guaranteed anymore.

Figure 1: R&R and timescales – The FANC approach (from Walter Blommaert, FANC, Session 6, Reims Conference)



3.2. Legal and policy context

- *Reversibility* is required by law in France.
- *Retrievability* is stipulated by law and regulations in Switzerland and the United States, and by government (legal requirements) in Germany and Finland (Decision in Principle (DiP)). In Germany, retrievability is a safety requirement.
- In Japan, a *stepwise approach* has been implemented in the legal framework which is understood to be *flexible* enough to be reversible.
- In Belgium, *retrievability* is not a legal requirement, but since the policy is to avoid actions which could rule out retrieval, some recommendations on this respect have been included in the Belgian strategic note.
- In the United Kingdom the Government has kept open the retrievability option.

3.3. Motivations for R&R

Motivations for R&R vary also among countries as it shown in Box 2.

Box 2: Motivations for R&R in different countries

France: The development and implementation of a geological disposal is a *social* and *political* process which has to be shared with institutional and non-institutional stakeholders. Reversibility is one element of this process.

Finland: Retrievability is related to the potential availability of alternative technology in nuclear waste management and, especially, options in geological disposal.

Germany: Retrieval for safety motivations:

- Operational Phase of the repository will last several decades and the most relevant constructions of the repository (sealing of shafts, drifts or caverns) will be built during or in the end of the operational phase.
- Correction of technical or scientific errors has to be possible.

Box 2: Motivations for R&R in different countries *(Con't)*

USA: The Nuclear Waste Policy Act (NWPA) of 1982:

Retrievability is maintained for *safety*, environment, or economic reasons;

Retrievability requirement prior permanent closure preserves the ability to act on new information for a specified time period (i.e., during the performance confirmation programme);

In addition, retrievability provides an opportunity to reverse a decision to consider spent nuclear fuel as waste; whereas, what may be considered as "waste" today could become a resource in the future.

Switzerland: Later generations should have the possibility to make use of new knowledge regarding disposal. Safety motivations for retrieval are considered as well:

"If there are indications of failure of the barrier system during the operational phase (and if adequate repair is impossible and the long-term safety of the geological repository can thus no longer be assured) the waste packages have to be retrieved**."**

3.4. Practical aspects

3.4.1. Timeframes for R&R

There seems to be a clear agreement between regulators that it is not feasible to maintain a constant level of retrievability over time.

Retrievability is *generally limited to the pre-closure phase,* **but** *legal requirements in some countries refer explicitly to the capability to remove waste during post-closure.*

As it is shown in Box 3a, national policies in Germany, Japan, Switzerland and the United Stated require retrievability through the operational phase until closure. In Belgium, reversibility (when the waste package is in its final configuration) is not explicitly required. However, reversibility, as part of good practice, is required. The Swiss Nuclear Energy Act states clearly that "the requirement for retrieval without undue effort ends with the final closure of the repository" (which means after "the monitoring phase").

However, laws, government decisions or regulations in Finland, Germany, and, in the USA (EPA) refer explicitly to the possibility of removing waste after closure of the facility as shown in Box 3b.

Box 3a Policy of retrievability until repository closure

Belgium: Up to regulatory closure/release, "reversibility and retrievability" can be considered as part of (or at least strongly related to) flexibility.

Japan: Retrievability until the time of repository closure when the long-term *safety is confirmed by the safety assessment.*

Germany: During the operating phase until sealing of the shafts or ramps, retrieval of the waste containers must be possible.

Switzerland: Up to the time of repository closure, retrieval of the waste has to be possible without undue effort (Nuclear Energy Act, Article 37). The mechanical stability of the disposal containers therefore has to be such that they can be retrieved without undue effort up until the end of the monitoring phase.

United States: Any repository constructed on a site approved ….. shall be designed and constructed to permit the retrieval of waste containers during an appropriate period of operation of the facility (NWPA). The NRC requires retrieval throughout waste emplacement and *performance confirmation program.*

Box 3b Policy of retrievability extending into the post-closure phase

Finland : At the time of DiP, the government stated that *retrieval should be feasible even in the post-closure phase*

> ("**Retrieval of the waste canisters from the repository shall be feasible** during the period in which the engineered barriers are required to provide practically complete containment of the disposed radioactive substances")
>
> In practical application, technical steps must be reversible for safety reasons. Additionally, demonstration of technical feasibility of retrieval and evaluation of cost of retrieval are required in the application for construction of the repository.

German regulation requires: demonstration of technical feasibility to recover wastes up to *500 year* after closure, *(specifying that the capacity to handle the waste containers must be guaranteed for a period of 500 years in case of recovery from the decommissioned and sealed final repository).*

EPA standards state that in accordance with the NWPA: Disposal systems shall be selected so that removal of most of the wastes is not precluded for a reasonable period of time after disposal. EPA standards have extended the requirement for retrievability beyond the operational period, as envisioned by the NWPA, to apply after closure of the facility (including sealing and backfilling of mined shafts).

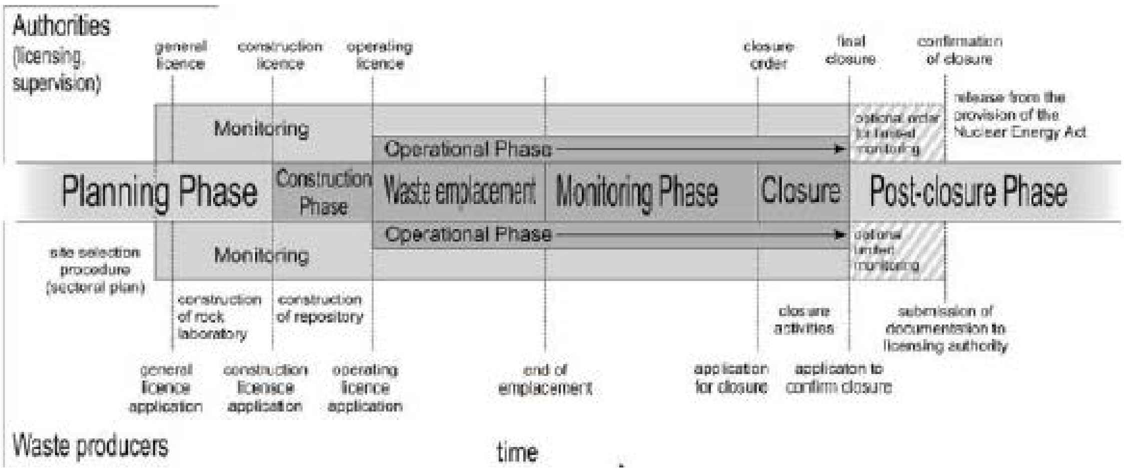
In establishing this requirement, EPA noted that "The intent of this provision was not to make recovery of waste easy or cheap, but merely possible in case some future discovery or insight made it clear that the wastes needed to be relocated." (Federal Register, Volume 50, page 38083, September 19, 1985).

3.4.2. Licensing aspects

Planning, implementation, operation and closure of a geologic repository typically proceeds by an incremental stepwise approach that last many decades and reversibility is part of the decision making process. *The licensing process* tends also to be developed via discrete decisions and authorisations

Normally, **hold points** are identified at which a deliberation should be made whether or not to reverse earlier decisions**.** Partial construction of disposal cells and emplacement of waste packages, decision of partial backfilling are examples of hold points for decisions. The example of the Swiss licensing process is provided in Figure 2.

Figure 2. Swiss decision making process (P. Hufschmied (ENSI), Session 3, Reims Conference)



The way and when R&R are considered in the licensing context differs from country to country. See Box 3c.

Box 3c - R&R in the licensing context of across countries

France

- The 2006 Act requiring reversibility defines the authorisation process giving a central role to the Parliament. Authorisation to create a disposal centre will be preceded by a public debate on the basis of a study prepared by the French national radioactive waste management agency (Andra) in 2012.
- The Andra study, the corresponding reports by the ASN and the National Review Board will be transmitted by the Government to the Parliamentary Office for Scientific and Technological Choice (OPECST), which will review the submission and report to the French National Assembly and Senate.
- A public debate will be organised during the second semester of 2013.
- On the basis of these elements the Government will present a law bill laying down the reversibility conditions and will set the minimum time during which, as a precautionary measure, disposal must be reversible (min 100y)
- Based on the license application transmitted to the Government at the end of 2014 and after the review by ASN the authorisation to implement the disposal facility will be issued by a decree from the State council adopted after a public inquiry. The closure will be authorised by an Act.
- The feasibility and conditions of reversibility[4] will have to be reassessed periodically.

Finland

Documents on the technical feasibility and cost of R&R are required in the Construction License application.

Research and monitoring during operation as well as scientific advances are taken into account for the license renewal and during the periodic safety reviews.

Belgium and Germany

Periodic safety reviews will be planned during the operational phase. For Belgium, they will be planned even up to the regulatory closure.

Switzerland

The **concept for retrieval** of the waste has to be presented to ENSI for review and approval together with the construction license application for the repository.

The **retrieval concept** has to contain an estimate of the expected radiation exposure of operating personnel and the local population.

Safety-relevant technologies for emplacing the backfill material (or its removal if retrieval is necessary), for retrieving waste packages and for the sealing of caverns and tunnels have to be tested and their operational reliability demonstrated.

3.4.3. Safety Requirements

The principle that safety must not be compromised by retrievability provisions is accepted internationally. This and other safety requirements are included in the regulations of some countries(see Box 3d).

4. From an international viewpoint, the meaning is here “retrievability”

Box 3d – Some specific safety considerations/recommendations related to R&R (list is not complete)

Belgium, Germany, UK

Durability of waste packaging and assessment of the effects of vault environment (corrosion/loss of integrity).

France

A maximum period during which reversibility[5] does not impact safety in operation and after closure should be submitted and justified in the application for the authorisation of creation of the disposal facility.

During the whole reversibility period, appropriate supervision and maintenance will be implemented and the corresponding information will be recorded, archived and made accessible.

Switzerland

The backfilling of the disposal excavations has to be in line with the requirements relating to long-term safety and the retrieval of waste packages without undue effort.

The **documentation** has to contain **information on interim storage** and any **subsequent conditioning of waste packages** in so far as this relates to properties of the waste packages that deviate from the documented standard design and the information is relevant for possible retrieval of the waste or long-term safety.

3.4.4. Example questions needing to be addressed regarding safety

- How (based on what information) do we determine on the duration of the retrievability period?
- How do we cope with the safety and security aspects related to having the repository accessible for a long time?
- Are there additional monitoring and security measures to be set up?
- How do we monitor the safety related long-term processes in the repository over a very long period of time?
- Removing aging fuel from disposal cells and moving it to the surface creates new safety and security issues. How should it be handled?
- How to handle damaged waste packages?
- Issues related to storage and re-conditioning of retrieved packages.
- Associated costs?
- How to clarify the meaning of closure, distinguishing between:
  - Technical or physical closure: sealing and backfilling of mined shafts which is followed by a post-closure compliance surveillance period (active institutional control and monitoring) (need authorisation).
  - Regulatory closure: after submission of the documentation for closure confirmation (to be explained).
- Etc.

5. From an international viewpoint, the meaning is here “retrievability”.

3.5. Stakeholder confidence aspects

Stakeholder confidence in the safety of a repository is necessary. The ultimate goal is to *build sufficient confidence* in the long term safety for transitioning the repository to an intrinsically safe phase without the need for an active presence of man (decision on repository closure, monitoring, oversight).

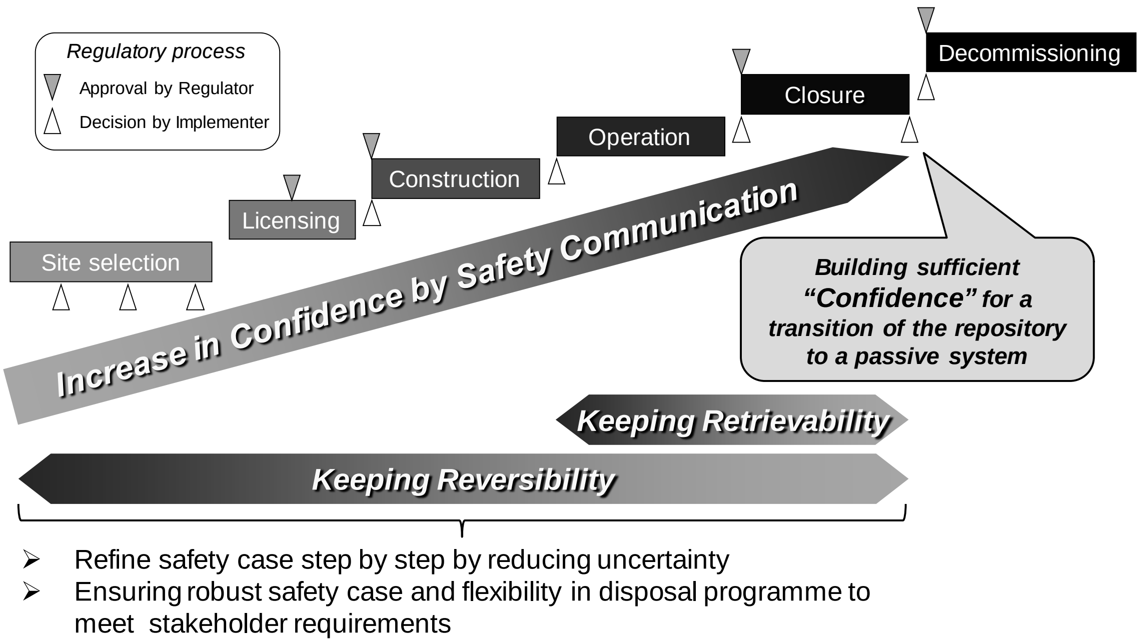
From the regulatory point of view of communication, two aspects are relevant to confidence building:

- *reversibility* of decisions during the implementation process;
- *retrievability* of part of the emplaced waste or its entirety.

Keeping retrievability and reversibility before closure could increase confidence in the final closure decision. Regulators have to be prepared to explain these issues to the different stakeholders and its application or use along the regulatory process. This was recognised already in a 2003 brochure (NEA 2003) and is currently emphasised also in the corresponding updated publications (NEA 2012c).

A scheme of the link between repository development and regulatory process with the process of increasing confidence considering R&R is shown in Figure 3.

Figure 3: Role of R&R for confidence building (Source: S. Shiroya, Session 3, Reims Conference)



4. Conclusions

Reversibility and retrievability requirements have been introduced in a number of countries at the legislative or policy levels (France, USA, Switzerland, Finland, Germany). In other countries R&R is considered as introducing flexibility in the stepwise process (Belgium, Japan, UK).

These requirements have been often related to social pressures in the direction of avoiding irreversible steps or even of preserving the ability to participate in future decision making, rather than of specifically requiring ease of retrieval. The ability to access materials that may become valuable at a future time and the ability to continue to directly monitor conditions in the repository are dominant social demands. Further demands for provisions that would ease retrieval may be motivated by unfamiliarity with (or lack of confidence in the maturity of) the disposal technology, by discomfort with the concept of purely passive safety without any means of oversight or active control, and/or by a desire to avoid making decisions today that may preclude different actions in the future.

However more specific motivations have been expressed such as taking the advantage to use alternative technologies in nuclear waste management (e. g. reprocessing spent nuclear fuel) or making use of new knowledge regarding disposal (Finland, Sweden, USA, Switzerland). A few countries have introduced R&R for safety-related reasons (correction of technical or implementation errors) and in this case express the need to extend the waste emplacement phase by a performance confirmation or monitoring phase (USA, Switzerland, Germany).

The level of integration of R&R provisions in the regulatory guidance for safety depends on the nature of the motivations for R&R. When R&R is required by law or government, safety guidance, at a minimum, states that provisions to ensure R&R should be taken into account but that these provisions should not compromise the operational and long-term safety of the disposal facility. When the motivation for R&R includes safety, these requirements are more detailed and are associated with specific technical demands or organisational requirements.

The most complex issue is the definition of a retrievability period. In the long term, attempting to facilitate retrievability by keeping a repository open longer than otherwise necessary could become detrimental to safety (e.g. a facility designed to be safe when properly sealed and closed may not be as safe if it is abandoned without sealing and closure, and keeping a repository open for a long period of time may increase the risk of this occurring). If there is an issue of retrievability versus safety, it is generally agreed that safety must come first.

A number of countries consider that retrieval must be possible before closure, when interim storage facilities are still existing and handling and transfer equipments are available. On a limited time frame after closure, when the integrity of the waste package is not yet affected, some countries consider that retrieval ought to still be possible although it may be costly (Belgium, Finland, Germany, USA). In any case the evaluation of cost and the radiological doses are needed by the regulators to evaluate the analysis of retrieval.

During the Reims conference, much of the discussion related to how regulatory agencies respond to and enforce the reversibility and retrievability policy requirements that have been established by government or parliament. Open questions in this respect include how a future decision to retrieve would be taken, and how safety and security would be assured at that time. It was pointed out as well that unforeseen reversals of decisions can take place in any programme, and an important question to consider would be whether such reversals should take place within a predefined process or not, which would imply the existence of pre-agreed rules of reversing decisions.

From the conference some general insights may be drawn on possible regulatory requirements:

- The feasibility and conditions of reversibility during the maximum period for R&R will have to be reassessed periodically at hold points. The absence of impact of retrievability provisions on safety during operation and after closure will have to be documented.
- Retrievability can be implemented in the framework of a stepwise process. The construction and operation arrangements are implemented under clear decision-making processes involving stakeholders. Periodical reassessments of the feasibility of retrieval (*retrievability*) should be made, in particular when safety reassessments are performed;
- During the whole reversibility period, provisions have to be implemented in order to ensure that the necessary and useful information is collected, stored and accessible and that the necessary equipment is available.

- Provisions for retrievability of the waste packages – if required – should include consideration of conditions for actual retrieval operations. This may include considerations about funding and about the availability of storage and reconditioning facilities.

Some countries have introduced technical safety requirements associated with R&R and associated R&D programs to demonstrate retrievability. Finland requires technical feasibility, Switzerland asks for full tests of removal of backfill, retrieving waste packages and demonstration of operational reliability. Other countries consider/recommend durability of waste packages (Belgium, Germany, United Kingdom).

One main finding from the Reims conference is that reversibility and retrievability are not requirements for long-term safety. They are about implementing a process that responds to ethical and precautionary obligations without compromising safety. Intrinsic, long-term safety remains the first priority and ultimate goal. On the other hand, technical safety-first or safety-only is a necessary but not a sufficient message to advance repository development. Dialogues on reversibility and retrievability can contribute to the understanding and eventual ownership of the concept by a larger part of society. Through this process, R&R can provide extra assurance that long-term safety is being achieved.

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Annex 1 – List of abbreviations and acronyms

Andra	French National Radioactive Waste Management agency
ASN	French Nuclear Safety Authority
BMU	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (Germany)
CSN	Nuclear Safety Council (Spain)
DiP	Decision-in-principle
EA	Environmental Agency (United Kingdom)
ENSI	Swiss Federal Nuclear Safety Inspectorate
EPA	Environmental Protection Agency (United States)
FANC	Federal Agency for Nuclear Control (Belgium)
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit (Germany)
NISA	Nuclear and Industrial Safety Agency (Japan)
NRC	Nuclear Regulatory Commission (United States)
NSC	Nuclear Safety Commission (Japan)
NWPA	Nuclear Waste Policy Act (United States)
OPECST	Parliamentary Office for Scientific and Technological Choice (France)
R&R	Reversibility and Retrievability
RWMC	Radioactive Waste Management Committee
SSM	Radiation Safety Authority (Sweden)
STUK	Radiation and Safety Authority (Finland)