

# Stakeholder Engagement in the Implementation of a Geological Disposal for Radioactive Waste

## Main Report

OPERA-PU-ECN121&122&123&124

Radioactive substances and ionizing radiation are used in medicine, industry, agriculture, research, education and electricity production. This generates radioactive waste. In The Netherlands, this waste is collected, treated and stored by COVRA (Centrale Organisatie Voor Radioactief Afval). After interim storage for a period of at least 100 years radioactive waste is intended for disposal. There is a world-wide scientific and technical consensus that geological disposal represents the safest long-term option for radioactive waste.

Geological disposal is emplacement of radioactive waste in deep underground formations. The goal of geological disposal is long-term isolation of radioactive waste from our living environment in order to avoid exposure of future generations to ionising radiation from the waste. OPERA (OnderzoeksProgramma Eindberging Radioactief Afval) is the Dutch research programme on geological disposal of radioactive waste.

Within OPERA, researchers of different organisations in different areas of expertise will cooperate on the initial, conditional Safety Cases for the host rocks Boom Clay and Zechstein rock salt. As the radioactive waste disposal process in The Netherlands is at an early, conceptual phase and the previous research programme has ended more than a decade ago, in OPERA a first preliminary or initial safety case will be developed to structure the research necessary for the eventual development of a repository in The Netherlands. The safety case is conditional since only the long-term safety of a generic repository will be assessed. OPERA is financed by the Dutch Ministry of Economic Affairs and the public limited liability company Electriciteits-Produktiemaatschappij Zuid-Nederland (EPZ) and coordinated by COVRA. Further details on OPERA and its outcomes can be accessed at [www.covra.nl](http://www.covra.nl).

This report concerns a study conducted in the framework of OPERA. The conclusions and viewpoints presented in the report are those of the author(s). COVRA may draw modified conclusions, based on additional literature sources and expert opinions. A .pdf version of this document can be downloaded from [www.covra.nl](http://www.covra.nl)

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Title: Stakeholder Engagement in the Implementation of a Geological Disposal for Radioactive Waste (Main Report)

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## List of abbreviations

CCS	Carbon Capture & Storage
CORA	Commissie Opslag Radioactief Afval
COVRA	Central Organisation for Radioactive Waste (in Dutch: Centrale Organisatie Voor Radioactief Afval)
EBS	Engineered barrier system
ECN	Energy research Centre of The Netherlands (Energieonderzoek Centrum Nederland)
EIA	Environmental Impact Assessment
EURATOM	European Atomic Energy Community
FP7	7 <sup>th</sup> Framework Programme (of EURATOM)
HADES	High Activity Disposal Experimental Site
HLW	High-level waste
IAEA	International Atomic Energy Agency
IBC	Isolation, Control and Surveillance (Isoleren, Beheersen en Controleren)
IGD-TP	Implementing Geological Disposal - Technology Platform
LILW	Low- and intermediate-level waste
MoDeRn	Monitoring Developments for Safe Repository Operation and Staged Closure (FP7 Project)
NEA	Nuclear Energy Agency
NPP	Nuclear power plant
NRG	Nuclear Research and consultancy Group
OECD	Organisation for Economic Co-operation and Development
OPERA	Research Programme for Final Disposal of Radioactive Waste (OnderzoeksProgramma Eindberging Radioactief Afval)
OSC	OPERA Safety Case
OSCAR	OPERA Safety Case for Radioactive Waste Disposal (OPERA Project)
PEST(LE)	PESTLE (Political, Economic, Social, Technological, Legal and Environmental) or PEST analysis
RESTAC	REtrievability and STAged Closure (OPERA Project)
RIVM	National Institute for Public Health and the Environment (Rijksinstituut voor Volksgezondheid en Milieu)
RWM	Radioactive Waste Management
SEA	Strategic Environmental Assessment
TNO	Netherlands Organisation for Applied Scientific Research
URL	Underground Research Laboratory
WMO	Waste Management Organisation

## Summary

Radioactive waste management (RWM) is a topic with diverging perspectives among societal actors. There is a need for analysing the specific views of Dutch stakeholders, their perspectives and expectations on RWM in the Netherlands, for developing potential strategies to effectively engage these stakeholders in the implementation process of a geological disposal for radioactive waste. Since 1993 retrievability of radioactive waste is an integral part of the Dutch policy on RWM, but currently The Netherlands lack explicit legislation, guidelines or technical/strategical visions with regard to the exact technical content of the term 'retrievability'. Within the framework of the five-year research programme for the geological disposal of radioactive waste - *OPERA* - the projects *ENGAGED* and *RESTAC* have been carried out to address the above-mentioned needs. These two projects together cover the tasks within Work Package 1.2 on '*Political requirement and societal expectations*' of the *OPERA Research Plan*. This report presents the main results of both projects. In addition to literature surveys, the results of both projects are based on several in-depth interviews with a selected group of stakeholders, an expert scenario workshop, and a stakeholder workshop. The main result of *ENGAGED* is a set of recommendations regarding the design of the stakeholder engagement in the implementation of a geological disposal for radioactive waste in the Netherlands. In *RESTAC* recommendations are given regarding the specification of the Dutch requirement for retrievability, and an interpretation of staged closure, the stepwise decision process towards closure of a repository, in the light of retrievability, reversibility of decisions and stakeholder participation.

## Samenvatting

Over het omgaan met radioactief afval verschillen diverse maatschappelijke actoren van mening. Daarom is het nodig een analyse te maken van de specifieke standpunten, perspectieven en verwachtingen rond het Nederlands afvalbeleid van Nederlandse stakeholders, om strategieën te ontwikkelen om hen effectief te betrekken bij het proces van implementatie van een geologische berging voor radioactief afval. Sinds 1993 vormt terugneembaarheid van het radioactief afval een centraal onderdeel van het Nederlandse afvalbeleid, maar tot op heden ontbreekt in Nederland nog expliciete wetgeving, richtlijn of technische /strategische visie met betrekking tot de precieze technische inhoud van de term 'terugneembaarheid'. In het kader van het vijfjarig onderzoeksprogramma voor de geologische berging van radioactief afval - *OPERA* - zijn de projecten *ENGAGED* en *RESTAC* uitgevoerd om de bovengenoemde behoeften te adresseren. Samen dekken deze twee projecten de taken binnen het werkpakket 1.2 over '*Politieke randvoorwaarden en maatschappelijke verwachtingen*' van het *OPERA-onderzoeksplan*. Dit rapport bevat de belangrijkste resultaten van beide projecten. Naast literatuuronderzoek, zijn de resultaten van beide projecten gebaseerd op een aantal diepte-interviews met een selecte groep van stakeholders, een expert scenario workshop en een stakeholder workshop. Het belangrijkste resultaat van *ENGAGED* is een stel aanbevelingen over hoe stakeholders actief betrokken kunnen worden bij de implementatie van een geologische berging voor radioactief afval in Nederland. In *RESTAC* worden aanbevelingen gedaan voor de specificatie van de Nederlandse eisen voor terugneembaarheid, en een interpretatie van gefaseerde sluiting, het stapsgewijze besluitproces tot sluiting van een eindberging, in het licht van terugneembaarheid, omkeerbaarheid van beslissingen en stakeholderparticipatie.

# 1. Introduction

## 1.1. Background

The five-year research programme for the geological disposal of radioactive waste - OPERA - started on 7 July 2011 with an open invitation for research proposals. In these proposals, research was proposed for the tasks described in the OPERA Research Plan [3]. The present report presents the combined outcomes of the OPERA projects *ENGAGED*<sup>1</sup> [1] and *RESTAC*<sup>2</sup> [2]. Together these projects cover the tasks in Work Package 1.2 on ‘*Political requirement and societal expectations*’ of the *OPERA Research Plan* [3]. *ENGAGED* covers Task 1.2.1 (Arena or stakeholder analysis), Task 1.2.2 (Legal requirements), and Task 1.2.4 (Public & stakeholder involvement), while *RESTAC* covers Task 1.2.3 (Retrievability and staged closure).

Radioactive waste management (RWM) is a topic with diverging perspectives among societal actors. In the OPERA research plan, a general need is noted for an analysis of potential (public) stakeholders and their perspectives and expectations for developing potential strategies to effectively engage these stakeholders in the design and implementation process of the geological disposal of radioactive waste.

Furthermore, since 1993 retrievability of radioactive waste is an integral part of the Dutch policy on RWM. Whereas the objective of retrievability has been discussed and worked out in more detail by some other countries, it is observed in the OPERA research plan currently The Netherlands lack explicit legislation, guidelines or technical/strategical visions with regard to the exact technical content of the term ‘retrievability’.

The projects *ENGAGED* and *RESTAC* have been carried out to address the above-mentioned needs, and their main findings and recommendations are summarized in this report.

## 1.2. Objectives

This report presents the main results of the *ENGAGED* and *RESTAC* projects. The objectives of these projects are:

- to investigate how the decision-making process on long-term disposal of radioactive waste should be arranged;
- which requirements and preconditions should be met, in order to achieve socially accepted decisions;
- and finally, what would be the role of reversibility, retrievability, and staged closure in the disposal of radioactive waste.

The main objective of *ENGAGED* is the development of a set recommendations for the next decade regarding the design of the stakeholder process around the implementation of a geological disposal in The Netherlands. In *RESTAC* focus is directed towards the specification of the Dutch requirement for retrievability, and an interpretation of staged closure, the stepwise decision process towards closure of a repository, in the light of retrievability, reversibility of decision and stakeholder participation.

<sup>1</sup>*ENGAGED*: End repository Network Geared towards Actor Groups involvement and Effective Decision-making

<sup>2</sup>*RESTAC*: REtrievability and STAged Closure



### 1.3. Realisation

The work presented in the present report has been performed by a Consortium consisting of the Dutch research organisations ECN, TNO and NRG. As a subcontractor, DuneWorks contributed to Task 1.2.4. Ms. Jantine Schröder (SCK•CEN) and Ms. Anne Bergmans (University of Antwerp) provided input based on their experiences with the Belgian and other countries' cases, notably with regard to the objectives and methodologies of this study.

This study is the first national stakeholder study in The Netherlands related to radioactive waste disposal since the CORA research programme (1995-2001, see [4]). It is an exploratory study to gain experience with stakeholder involvement in geological disposal of radioactive waste for the specific conditions present in The Netherlands. Although a large amount of international guidance and practical experience on stakeholder involvement in radioactive waste management is available in the literature (see Chapter 5), as will be pointed out in Chapter 8, general approaches and recommendations are not easily translated to the Dutch situation: due to the Dutch policy of long-term interim storage - the construction of a final disposal facility is scheduled no sooner than in 100 years - no concrete decisions are foreseen in the near future.

Due to the long timespan toward the implementation of a geological disposal facility in The Netherlands and the exploratory nature of the project, a qualitative and stepwise research approach was taken, based - where possible - on existing literature on the concerned subject, strongly focussing on the specific challenges of stakeholder involvement in The Netherlands. One of these challenges was the rather low interest of stakeholders in this topic, partially due to the lack of clear political objectives for the next decade.

Simultaneously to this study, commissioned by the Ministry of Economic Affairs the Rathenau Institute has conducted a study aimed at developing a vision on public participation in decision-making on geological disposal in The Netherlands [5]. The research in the projects *ENGAGED* and *RESTAC* is complementary to this Rathenau study, being performed in a stepwise process to identify strategies and develop recommendations for involving stakeholders in a future decision-making trajectory.

This qualitative research process consisted of the following steps:

1. Literature review;
2. Stakeholder inventory;
3. Exploratory in-depth interviews;
4. Scenario development and expert workshop;
5. Stakeholder workshop on decision-making and participation;
6. Development of a participative outline of a staged closure decision-making process;
7. Robust recommendations and strategies to effectively involve stakeholders in decision-making towards the realisation of a radioactive waste repository.

As a first step, *literature review* was performed with respect to the current international state-of-the-art of stakeholder involvement in radioactive waste management (RWM), which was complemented by more general literature on stakeholder interaction in other related fields. Furthermore, literature on the concepts of retrievability, reversibility, stepwise decision-making, and on the role of monitoring in waste disposal was studied.

To investigate how stakeholders may be involved in a meaningful way in the decision-making trajectory leading towards geological disposal, existing stakeholder groups



in The Netherlands were identified and their perspectives on RWM were explored (*stakeholder inventory*).

Based on the *stakeholder inventory*, exploratory *in-depth interviews* were organized with the main stakeholders and experts identified, in particular to explore their views and concerns.

Regarding *scenario development* an explorative scenario methodology was proposed [6] that was discussed in the *expert workshop* (see Chapter 8).

The expert workshop was used to substantiate the exploratory scenario methodology, which subsequently was applied in a *stakeholder workshop* on decision-making and participation, organized on 10 September 2014.

A participative *outline of a staged closure decision-making process* was developed, based on the literature review, the in-depth expert interviews and supported by discussions on reversibility, retrievability and staged closure at the stakeholder workshop. The setup of the stakeholder workshop resembled that of a focus group, with individual expression of opinions alternated by group discussions, and in which no consensus among participants needed to be achieved.

Based on the lessons learned from the literature review, the interviews, and both workshops, in the final chapter, concrete *recommendations* have been worked out. These recommendations address the involvement of stakeholder and aspects related to retrievability, reversibility and stepwise decision-making. The recommendations distinguish between the next decade and the long term.

#### 1.4. Contents of the report

The deliverables of the projects *ENGAGED* and *RESTAC* comprise five reports:

- The present main report;
- Appendices to the main report [7];
- A topic report on retrievability, staged closure and monitoring [62];
- An interim report [8] and a final report on reference values<sup>3</sup>.

This main report consists of three parts:

- Chapters 2 to 5 introduce and discuss key aspects and the current state-of-the-art of RWM for the interested reader less familiar with the general subject of radioactive waste disposal;
- Chapters 6 to 8 contain descriptions and results of the performed empirical research;
- Chapters 9 to 10 contain conclusions, lessons learned and recommendations derived from the previous chapters.

Chapter 2 introduces the general principles of RWM, followed by a condensed overview of the most relevant features of the Dutch policy on radioactive waste. To put this research in the broader context of the OPERA research programme, this chapter continues with a short description of the ‘*safety case*’ methodology, which is believed to be a suitable approach that answers many of the concerns and suggestions expressed in the later chapters. This chapter concludes with a reflection on the purpose and structure of the

<sup>3</sup>to be submitted in 2016

current OPERA research programme and the intended OPERA Safety Case, to which the projects *ENGAGED* and *RESTAC* provide input.

The principles of stepwise decision-making in RWM are handled in Chapter 3. The implementation of geological disposal is seen as a stepwise process that can be split into different stages, and thus answers to the specific challenges to organise the long term process of radioactive waste disposal. Although The Netherlands is in the first stage of the implementation process, it is necessary to have a basic understanding of the overall process for conducting a meaningful discussion on the topic. Therefore the major decision points in this staged process are described in this chapter as well.

*'Retrievability'* and *'reversibility'* are important elements of the Dutch policy on radioactive waste disposal, and general views and features are elaborated in Chapter 4.

The stakeholder involvement and the related organisational aspects, as well as the essence of the international experience and views are described in Chapter 5.

Chapter 6 contains further elaboration of stakeholder inventory, followed by in-depth interviews in Chapter 7. Scenario development and stakeholder workshops are elaborated in Chapter 8.

In Chapter 9 an integrated description is given for an outline of a generic staged closure process in The Netherlands.

Finally, Chapter 10 presents recommendations and strategies to effectively involve stakeholders in decision-making towards the realisation of a radioactive waste repository, as well as recommendations on retrievability, reversibility and the staged closure decision-making process.

Figure 1-1 presents the contents of chapters and the relation between these chapters.

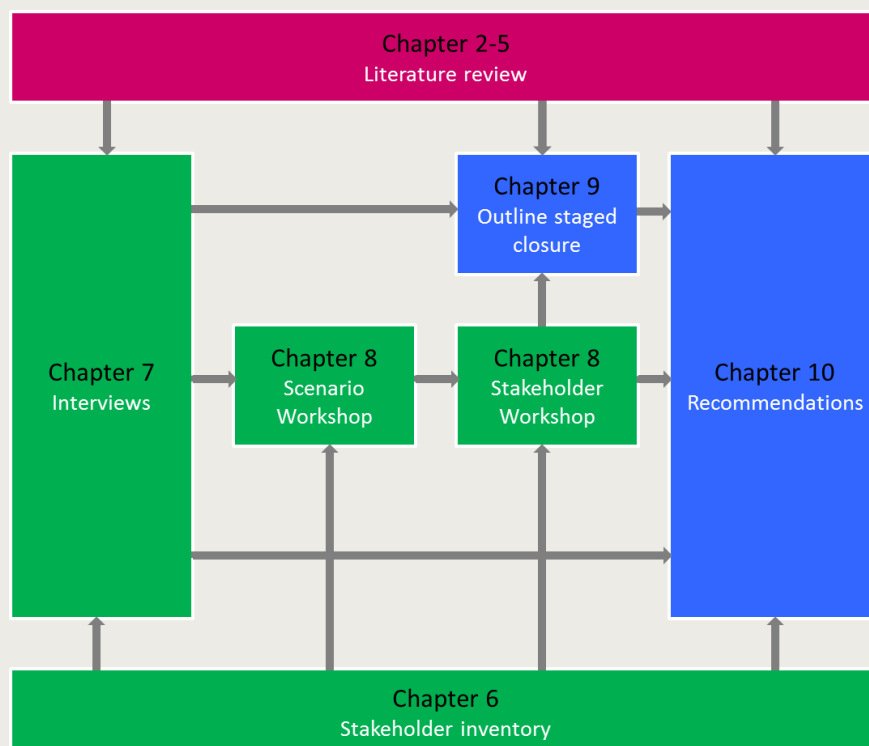


Figure 1-1: Contents of and the relation between chapters of this study

## 2. Radioactive waste management

### 2.1. General principles

Radioactive waste arises from energy production by nuclear power, and medical, industrial and research applications. One of the most challenging tasks of *radioactive waste management* is the safe disposal of long-living radioactive waste that must be isolated from the human environment for thousands of years. In 1995, IAEA provided nine fundamental principles of radioactive waste management [9], that can be shortly summarized as follows:

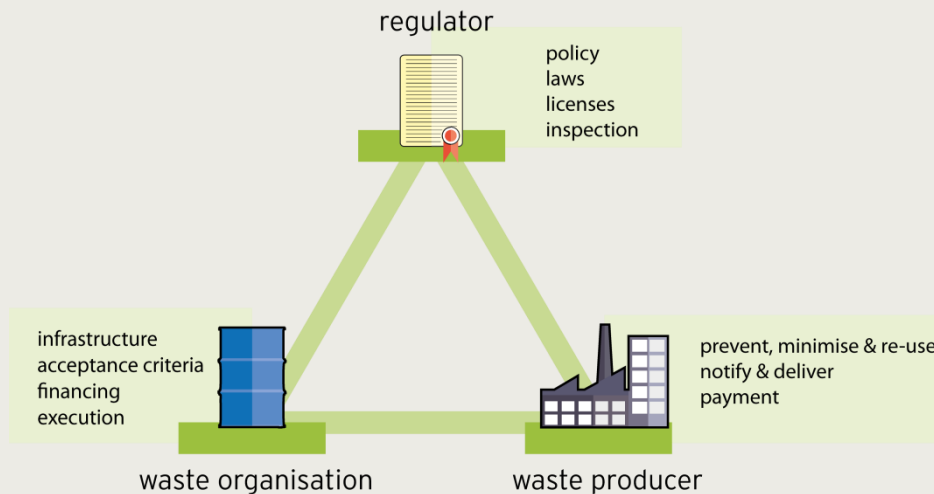
- **Protection of Human Health:** Radioactive waste shall be managed in such a way as to secure an acceptable level of protection for human health.
- **Protection of the environment:** Radioactive waste shall be managed in such a way as to provide an acceptable level of protection of the environment.
- **Protection beyond national borders:** Radioactive waste shall be managed in such a way as to assure that possible effects on human health and the environment beyond national borders will be taken into account.
- **Protection of future generations:** Radioactive waste shall be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today.
- **Burdens on future generations:** Radioactive waste shall be managed in such a way that will not impose undue burdens on future generations.
- **National legal framework:** Radioactive waste shall be managed within an appropriate national legal framework including clear allocation of responsibilities and provision for independent regulatory functions.
- **Control of radioactive waste generation:** Generation of radioactive waste shall be kept to the minimum practicable.
- **Radioactive waste generation and management interdependencies:** Interdependencies among all steps in radioactive waste generation and management shall be appropriately taken into account.
- **Safety of facilities:** The safety of facilities for radioactive waste management shall be appropriately assured during their lifetime.

The above list gives a very accessible overview on the main principles, although currently more elaborated IAEA safety principles are applicable, documented in [10] and an underlying set of *General Safety Requirements*, *General Safety Guides*, *Specific Requirements*, and *Specific Safety Guides* [11]. Radioactive waste management comprises different stages including waste collection and conditioning, interim storage, and - dependent on the waste properties - storage in near-surface disposals or deep underground disposal facilities. *Geological disposal* in deep underground formations describes the disposal of solid waste in stable geological formations that provides long-term isolation from the biosphere. It is generally seen as the safest option for the disposal of radioactive waste on the long term [12]. Four objectives of geological disposal are defined by IAEA [13, p.2f]:

- To contain waste until most of the radioactivity, and especially that associated with shorter lived radionuclides, has decayed;
- To isolate the waste from the biosphere and to substantially reduce the likelihood of inadvertent human intrusion into the waste;
- To delay any significant migration of radionuclides to the biosphere until a time in the far future when much of the radioactivity will have decayed;

- To ensure that any levels of radionuclides eventually reaching the biosphere are such that any radiological impacts in the future are acceptably low.

The implementation of a geological repository for long-lived radioactive waste is a complex and lengthy process. In IAEA documents [e.g. 14], three principal actors are distinguished: the *waste producer*, the *waste organisation* and the *regulator* (Figure 2-1).



**Figure 2-1: “Classical” IAEA triangle of main actors.**

For the specific step of radioactive waste disposal, the IAEA [15; p.17ff] focuses on three actors responsible for the implementation of a safe disposal of radioactive waste:

- the government;
- the regulatory body;
- the operator.

The *government* has to establish an appropriate governmental, legal and regulatory framework in which responsibilities are clearly allocated, including:

- definition of the national policy for the long term management of radioactive waste;
- definition of the overall process for the development, operation and closure of disposal facilities and specification of the steps in development and licensing of facilities of different types;
- definition of the processes for decision-making and the involvement of interested parties;
- securing of financial and other resources;
- setting clearly defined legal, technical and financial responsibilities for organizations that are to be involved;
- ensuring that the necessary scientific and technical expertise remains available.

The responsibilities of the *regulatory body* or *regulator* include the establishment of regulatory requirements and setting out procedures for the various stages of the licensing process. The regulatory body sets conditions for the development, operation and closure of disposal facility and activities necessary to ensure that these conditions are met. The regulatory body has to engage in dialogue with waste generators, the operators of the

disposal facility and interested parties to ensure that the regulatory requirements are appropriate and practicable.

The *operator* of a disposal facility for radioactive waste is responsible for its safety. The operator conducts safety assessment and develops and maintains a safety case, and manages all the necessary activities for site selection and evaluation, design, construction, operation, closure and, if necessary, surveillance after closure. The operator also has the responsibility to engage in dialogue: with the producers (to ensure the waste accepted meets conditions of the safety case and the general waste acceptance criteria, and also with stakeholders. The work will be performed in accordance with a national strategy, in compliance with the governmental and regulatory requirements and within the legal and regulatory infrastructure. The operator has to conduct or commission the research and development work necessary to ensure that the planned technical operations can be practically and safely accomplished, and to understand and to support the understanding of the processes on which the safety of the disposal facility depends.

The term *waste management organisation* (WMO) that is often used in this context and throughout this report, is strongly related to the term *operator*: The *waste management organisation* is usually the operator of radioactive waste disposal facilities, but may also serve other waste management and decommissioning roles, e.g. the interim storage of radioactive waste in the period before geological disposal [16].

There is a strong awareness in radioactive waste management that for decision-making, due to the long timescales of the implementation process, changes in society and societal values and expectations need to be addressed. Values such as health, environmental protection and safety are recognized to be increasingly important in the last decades, and trends towards participatory democracy demands new forms of risk governance. This results in the necessity of a decision-making process that includes a large number of stakeholders and new forms of dialogue, towards an “engage, interact and co-operate”-model [17]. Not only scientific and engineering aspects of waste management are of importance, but also the ability to communicate and to adapt to new contexts is identified as a relevant contributor to public confidence in the safe disposal of radioactive waste. Key features of a successful implementation strategy are [17, p.19]:

- broad agreement in society regarding the ethical, economic, and political appropriateness of the waste management solution;
- broad-based confidence in the practicality and long-term safety of the relevant technology;
- broad-based confidence in organisational structures, legal framework, and regulatory review process for the development of the waste management facility, including agreement on development stages.

Based on experience in performing Environmental Impact Assessments (EIA) in several fields, the following main public concerns with respect to communication and the organisation of a participation process have been identified [17, p.22]:

- Administrative difficulties with public information sessions: e.g. lack of advertising, scheduling problems, inappropriate locations, format stifling thorough debates, language of information, information which is not user-friendly;
- No, or not enough, funding for public review and intervening activities;
- Closer consultations between the government and industry;
- Information not in their preferred language;
- Perception that comments are not taken into account;
- Not enough attention paid to social concerns and on how to redress them;

- Sense of no ongoing control.

When setting up a radioactive waste management policy, awareness of these concerns is recommended, as well as preventive and, if necessary, corrective actions in order to deal with them.

A key concept in radioactive waste management is the *stepwise* nature of *decision-making* with respect to the implementation trajectory, where any significant decisions should involve a broad range of stakeholders and a comprehensive public review. It is noted that often the (local) public is “*not willing to commit irreversibly to technical choices on which they have insufficient understanding and control*” [17, p.7]. At the same time, due to the long timescales involved, any decision on management options potentially involve stakeholders who have even not been born yet. The following overarching principles of public involvement and adaptive decision-making are defined in [17, p.11]:

- Decision-making should be performed through visible, iterative processes, providing the flexibility to adapt to contextual changes, e.g. by implementing a stepwise approach that provides sufficient time for developing a competent and fair discourse.
- Public involvement in decision-making processes should be facilitated, e.g. by promoting constructive and high-quality communication between individuals with different knowledge, beliefs, interests, values, and worldviews.

## 2.2. Radioactive waste management in The Netherlands

The Dutch policy on radioactive waste management is mainly based on three policy documents, namely the 1984 *Radioactive Waste Policy in The Netherlands; An outline of the Government's position* [18], the 1993 *Cabinet Position on Underground Disposal* [19] and the 2002 *Radioactive Waste Management; Policy Perspective 2002 - 2010* [20]. The main line of this policy is that hazardous waste has to be isolated, controlled, and surveyed according to the Dutch ‘IBC’ criteria [18, 21]. In order to do so, radioactive waste is stored in purpose-built aboveground structures for at least hundred years, after which geological disposal is foreseen. During this period of interim storage all necessary technical, economical, and social arrangements are to be made in such a way that geological disposal can really be implemented afterwards. This involves a clear choice concerning the ownership of the waste, developing appropriate financing schemes, resolving outstanding technical issues, preserving the expertise and knowledge, gaining public understanding of the waste management issues and building public support [22]. A further detailing of the Dutch policy is expected from the National Programme on Radioactive Waste Management, which is based on the EURATOM council directive 2011/70 from 2011 [23].

Until a geological disposal is in operation, all radioactive waste of the Netherlands is collected, conditioned and stored at dedicated storage facilities at COVRA (Centrale Organisatie Voor Radioactief Afval), that provides a safe solution for about a century and allows to investigate in more detail potential future disposal options. COVRA has the responsibility as *operator* and *waste management organisation* (see previous section). Since 1<sup>st</sup> January 2015 is the Autoriteit Nucleaire Veiligheid en Stralingsbescherming<sup>4</sup> (ANVS) the responsible regulator in The Netherlands.

Prior to OPERA, four national research programmes on radioactive waste disposal have been conducted (**Figure 2-2**), from which the last was performed in the period of 1996 - 2000 [24]. Based on that programme, currently two host rocks are considered for the

<sup>4</sup>Authority for Nuclear Safety and Radiation Protection



disposal of radioactive waste in The Netherlands: rock salt and Boom Clay [25, 26, 27]. Although basically the Dutch radioactive waste should be disposed in The Netherlands, a multinational solution, in which several (smaller) nuclear countries strive for a common disposal, is currently not excluded [28].

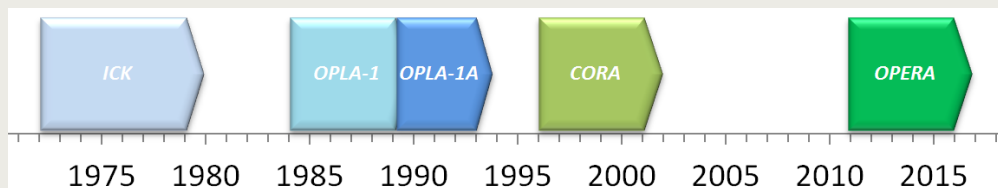


Figure 2-2: National research programmes on radioactive waste disposal in The Netherlands

### 2.3. The safety case methodology

In this section, the ‘*safety case*’ methodology is shortly described. Rather than presenting the full technical details of this methodology, for which we refer to the outcomes of OPERA Task 2.1, *Definition of the Safety Case*, this section focuses on the link or the embedding of the safety case in the larger societal perspective. In the first subsection, the general concepts of the safety case are shortly summarized. The second subsection focuses on the role and purpose of the current OPERA Safety Case. Additional information about the safety case can be found in e.g. [13, 17, 29]. Examples of existing safety cases can be found in [30, 31, 32], for an overview see also [33].

#### 2.3.1. General concepts

In response to the public and stakeholder concerns discussed in Section 2.1, in the 1990-es a methodology was developed, known as ‘*safety case*’ (e.g. [17, 34, 35, 36]). This methodology is based on the shared belief that societal confidence in the long-term safety of a disposal can be marked for most countries as a key challenge in the implementation of a geological disposal for radioactive waste. One of the first documents on the safety case methodology published by NEA in 1999 is called “*Confidence in the Long-term Safety of Deep Geological Repositories. It’s Development and Communication*” [34], defines a safety case as:

*“a collection of arguments, at a given stage of repository development, in support of the long term safety of the repository. A safety case comprises the findings of a safety assessment and a statement of confidence in these findings. It should acknowledge the existence of any unresolved issues and provide guidance for work to resolve these issues in future development stages.”*

Key elements of a safety case are summarized in **Figure 2-3**. The safety case methodology follows a structured, stepwise approach, recognizing that the development, implementation, operation and closure of a geological disposal facility will take place over a timespan of several generations. Different stages can be distinguished (see next Chapter), and moving forward from one stage to the next one requires decisions that are supported by an (updated) safety case providing arguments and evidence for the safety. A safety case also requires that the public and other interested parties should be involved in each of the key decisions steps (e.g. [37, p.42]).



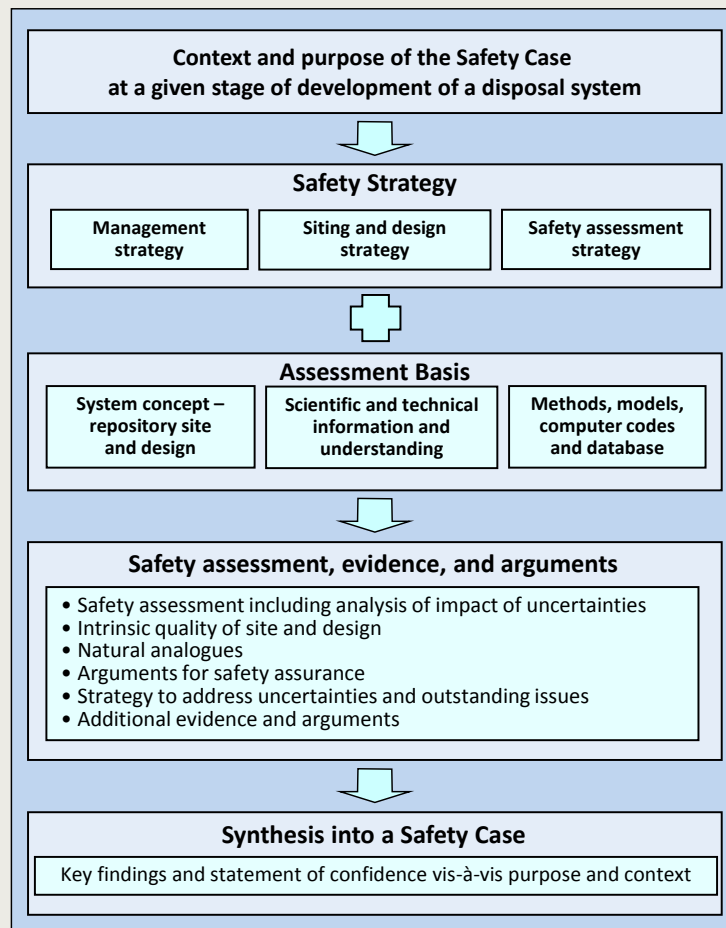


Figure 2-3: Components and structure of a safety case [29]

A safety case thus contains an evaluation of safety at a certain point in the stepwise implementation process, and the level of detail and complexity of the analysis can vary substantially: early assessments will focus on the long-term safety and feasibility of a generic disposal concept, while later assessments will address aspects as the optimisation of a disposal system in a given host rock, the compliance with regulatory requirements, and operational safety. The subsequent safety cases have to be fully documented and the evolution of the safety case and its outcomes should be transparent for all interested parties. This includes clear records of changes and developments, explanations of new data and argumentations for any changes with respect to previous used methods, approaches or constructional designs. All information that supports the safety assessment should be traceable. The methodology used for the safety assessment should be described clearly, and their underlying assumptions and methodological limitations should be discussed as well as remaining uncertainties.

A safety case has an important role in communicating the status quo of the ongoing research on radioactive waste disposal to stakeholders and the broader public. A key element of the safety case is the so-called '*safety statement*' that should provide a clear statement on the safety of a disposal concept, supported by a set of arguments. In addition, unresolved issues and remaining uncertainties at a certain stage should be indicated clearly. Each safety case can trigger an evaluation of the current RWM policy and progress made so far, and provide input for decisions on e.g. research priorities, or choices on barrier concepts, host rock, etc. A safety case should be reviewed and updated as

necessary prior to each major decision step, and alternative options should be presented and their pros and cons should be assessed.

Although scientific and technical aspects form the core of the safety case and the regulator is considered the primary audience [38], a safety case is also linked to societal values and expectations (e.g. what ‘risk’ can be considered ‘acceptable’). This also means that the audience for the safety case may differ between the stages of the process and the decision to be supported by it (see also Figure 3-1). These links are relevant because the disposal of radioactive waste is a controversial question of societal interest. A safety case should therefore answer stakeholders’ and society’s concerns and should address their demands and values. These concerns, demands and values should therefore firstly be known. To achieve confidence, the embedding of the safety case in a societal context should include the communication of the context of a given safety case and its particular outcomes, offered in a suitable manner to the different target groups of interest [39].

### 2.3.2. Purpose and structure of the OPERA Safety Case

While the safety case methodology provides general guidelines, the precise objectives, scope, structure and content of a national safety case for a particular stage has to be elaborated to fit within the specific context and needs of a prevailing national RWM programme.

The development of safety cases for disposal concepts in Boom Clay and rock salt has been defined as main objective of the OPERA programme [40, p.5], with focus on the long-term safety, but a more explicit objective for the OPERA Safety Case is not stated. However, there is a clear expressed awareness that OPERA is expected to be a starting point rather than provide ‘final’ answers, and that future research efforts are necessary: in the OPERA Research Plan [40, p.3 ] the OPERA Safety Case is described as a

*“first preliminary or initial safety case [...] to structure the research necessary for the eventual development of a repository in The Netherlands. The safety case is conditional since only the long-term safety of a generic repository will be assessed.”*

With respect to contextual aspects of the safety case it is noted that close collaboration with the Belgian research programme on radioactive waste disposal is seen as advantageous. A complementary approach of both programmes using - where applicable - the same methods, assumptions and parameter values is supposed beneficial because it is expected to

*“increase the confidence of public and stakeholders in the safety statement and arguments that support the long-term safety of the geologic disposal of radioactive waste in Boom Clay in Belgium and The Netherlands.” [3, p.17]*

With respect to the OPERA Safety Case structure and content, some introductory descriptions on the safety case in general and the OPERA Safety Case in particular are provided in the OPERA Research Plan [3, p.7ff], mainly following general description provided by NEA and IAEA. A set of so-called ‘safety functions’ for a disposal concept in Boom Clay is provided [3, p.9f]. These safety functions are an abstraction of the features the long-term safety is based on, and are the basis for the safety assessments to be performed. The OPERA Research Plan considers the elaboration of a more detailed structure of the safety case - including public and stakeholder related aspects - as a research task (WP2.1, *Definition of the Safety Case*, [3], see also [41, 36]. The responsibility for the preparation of the safety cases lies at the OPERA Programme Directorate (i.e. COVRA) [3, p.7]. COVRA has also established a *Safety Case Group* [3, p.7; 42].

Despite the temporal coincidence with the EU-directive 2011/70/EURATOM [23], when setting up the OPERA research programme in 2010, the OPERA Safety Case was not related to any concrete political decision to be made in mind. Neither does it represent a response to an explicitly manifested societal or political need. The OPERA research programme mainly covers the elements necessary to develop a national safety case for the disposal in Boom Clay<sup>5</sup>, based on the set of safety functions defined in [3, p.16]. The OPERA research programme follows the general structure of the safety case methodology as depicted in **Figure 2-3**. There was a clear awareness of the relevance to further investigate the embedding of the safety case in a societal context<sup>6</sup>.

The direct involvement of stakeholders in the preparation of the research programme on which the OPERA Safety Case has to be built, was limited to interested scientific and consultancy organisations<sup>7</sup>, COVRA, the responsible ministry and EPZ [43, p.3]. The definition of the existing societal context for the OPERA programme and the intended safety case was limited to the description of a number of political decisions in [40] and [3], with comparable content as summarized in the previous section. Because the relevance for a closer definition of the societal context was acknowledged, two work packages directly related to social-scientific research were identified in the Research Plan (WP1.2 and WP1.3, [3]), one related to further defining the societal context<sup>8</sup> and one related to communication. The tasks defined in these work packages include:

- Identification of affected stakeholders and other participants in decision-making;
- Identification of potential legal requirements, comparison with national and international stakeholder visions and evaluation whether these requirements answer public expectations and concerns sufficiently;
- Derivation of reference values as comparison basis for the outcomes of the quantitative safety evaluations;
- Definition of criteria for staging decisions and the actors that should be involved, and a critical evaluation whether the procedure proposed will result in a robust process and answers the political and public expectations in The Netherlands;
- Investigation of expectations of stakeholders and the public with respect to their involvement, and development of strategies for involvement and communication, with emphasize on current options;
- Investigation of effective and successful strategies for communication of the safety case outcome to the public.

The evaluation performed in this section and the bulleted list of topics given above describe the arena for the research of the projects ENGAGED and RESTAC (summarized in this report). In summary, instead of using *a priori* defined societal expectations, values and requirements, the current OPERA research programme wants to investigate different components for the societal embedding of the safety case. No clear political or societal assignment was given to the programme and the options to adapt the current research programme on basis of the outcomes of the related projects are limited. Nevertheless,

<sup>5</sup>and a single task related to the safety case in rock salt

<sup>6</sup>“social research” [43, p.3]

<sup>7</sup>Most of them are organized in a national stakeholder platform, *NORA (Netwerk Opberging Radioactief Afval)*. NORA promotes exchange of information between all stakeholders in the RWM process.

<sup>8</sup>resulting in the projects *ENGAGED* and *RESTAC*

new findings can still be considered in the OPERA Safety Case, e.g. by marking open questions, answering to expressed stakeholder concerns or suggesting future steps for the further development of the Dutch safety cases.

### 3. Principles of decision-making for the implementation of a geological disposal

#### 3.1. General views on a stepwise approach

The implementation of a geological disposal is seen as a stepwise process that can be split into different phases or stages [34, 17, 13]. In [17] it is stated that:

*"In long-term radioactive waste management, consideration is increasingly being given to concepts such as "stepwise decision-making" and "adaptive staging" in which the public, and especially the local public, are to be meaningfully involved in the review and planning of developments. The key feature of these concepts is development by steps or stages that are reversible, within the limits of practicability. This is designed to provide reassurance that decisions can be reversed if experience shows them to have adverse or unwanted effects. A stepwise approach to decision-making has thus come to the fore as being of value in advancing long-term radioactive waste management solutions in a societally acceptable manner."*

The stepwise approach is expected to facilitate public involvement and social learning [17]. About the potential involvement of stakeholders, in [17, p.17] it is stated that:

*"a "decision" no longer means opting for, in one go and for all time, a complete package solution. Instead, a decision is one step in an overall, cautious process of examining and making choices that preserve the safety and well-being of the present generation and the coming ones while not needlessly depriving the latter of their right of choice. Consideration is thus increasingly being given to the better understanding of concepts such as "stepwise decision-making" and "adaptive staging" in which the public, and especially the most affected local public, are meaningfully involved in the planning process.[...] In addition to the institutional actors, the public is involved at each step and also in reviewing the consequences of previous decisions. This is designed to provide reassurance that decisions may be reversed if experience shows them to have adverse or unwanted effects."*

#### 3.2. Major decision points

An example of key decision points to be considered in the staged implementation of a geological disposal facility is depicted in **Figure 3-1**. Generally, eight major decision points and the related actors can be distinguished<sup>9</sup>:

- Need for action;
- Disposal concept;
- Site selection;
- Construction;
- Operation;
- Closure;
- Post-closure;
- Post-licencing.

<sup>9</sup>Note that the terminology used differs slightly between publications.



**Figure 3-1: The typical sequence of key decisions in the implementation of a geological disposal and the responsible parties involved (adapted from [44])**

A generic timeline for decision-making in The Netherlands is presented in the OPERA Meerjarenplan [40] (see **Figure 3-2**).

In the remainder of this section, these major decision points are shortly presented. It should be noted that not all relevant decisions can be coupled to a particular decision point. Some are linked in a more symbolic manner (i.e. these decisions could also be made at other moments), and others might be reviewed and revised repeatedly in course of time (see also Section 3.3 on reversibility of decisions and retrievability of the waste).

### 3.2.1. Need for action

Based on the specific national context and the logistic boundary conditions (waste inventory, current policy on nuclear power, etc.), this decision step consists of the awareness for the need to find a safe solution for the long-term disposal of radioactive waste. In this step, a disposal programme will be initiated that ensures the implementation of a geological disposal. This may include the accumulation of scientific information and assessment of the necessary basis, the evaluation of possible sites and/or host rocks, the development of a disposal concept, the iterative performance of safety assessments which are supported by increasing experimental evidence, technical and regulatory reviews and public consultations [13].

An important part of a future safety case in this phase is called "safety strategy", which is a high-level approach that describes how a safe disposal should be achieved. In [34], three components of a safety strategy are distinguished:

- *"The overall management strategy of the various activities required for repository planning, implementation and closure, including siting and design, safety assessment, site and waste form characterisation and R&D. This management function keeps work focused on project goals, allocates resources to particular*



activities, and ensures that these activities are correctly carried out and co-ordinated;

- the siting and design strategy to select a site and to develop practicable engineering solutions, consistent with the characteristics of the selected site and the waste forms to be disposed; and
- The assessment strategy to perform safety assessments and define the approach to evaluate evidence, analyse the evolution of the system and thus develop or update the safety case."

Decision process	Research on final disposal		
	National - rock salt	National - Boom Clay	Multi-national
1984 - principal decision on interim storage and final disposal	Feasibility of retrievable final disposal in rock salt and Boom Clay formations in the Netherlands		
1993 - requisite of retrievability	Feasibility of retrievable final disposal in rock salt and Boom Clay formations in the Netherlands		
2002 - confirmation of feasibility of retrievable final disposal in rock salt and Boom Clay formations in the Netherlands -transfer of stock from COVRA to government; start of 100-year period of surface storage	Development of Safety Cases (SC-0: long-term safety) for final disposal in rock salt and Boom Clay in the Netherlands, update of cost estimate and exploration of societal aspects <sup>1</sup>		Feasibility study on multi-national final disposal facility; elaboration of implementation strategy
2015 - OPERA Final Report 2025 - Safety Case 1 2035 - Safety Case 2 2045 - Safety Case 3 2055 - Safety Case 4 2065 - Safety Case 5	Elaboration of final disposal concepts and possible implementation strategies (long-term safety, technical feasibility, operational safety, cost, monitoring, societal support, etc.); evolutionary development of Safety cases (SC-x)		In this period the research on national final disposal will be complementary to that on multi-national final disposal
2080 - selection of national or multi-national final disposal <sup>1</sup>	Detailed comparison possible options: prolonged surface storage, final disposal in the Netherlands in rock salt and Boom Clay formations; elaboration of potential site selection processes		
2100 - Selection of host rock for final disposal	Preparative studies, surface exploration, basic engineering of potential final disposal concepts in selected host rock type		
2115 - Selection of site for final disposal	Underground in-situ exploration at selected site, detailed engineering of the facility		
2130 - Start of operation of disposal facility			

**Figure 3-2: Outline of a stepwise decision-making process for a geological disposal facility in The Netherlands according to the OPERA Meerjarenplan [45]<sup>10</sup>**

In The Netherlands, the safety strategy is still in development [28]. The process has led to a number of governmental and policy decisions [18, 19, 20, 22], and has resulted in initial disposal concepts [46, 47, 27, 48] and their safety evaluations [25, 24, 26]. The current OPERA programme can be considered as part of this on-going process, ultimately leading to a stepwise, iterative refinement (see Figure 3-1) of actions to develop and evaluate the stepwise implementation of a safe geological disposal.

<sup>10</sup>English version of the figure in the OPERA Meerjarenplan [40]



### 3.2.2. Disposal concept

The decision concerning the most appropriate host rock/disposal concept for a given waste inventory, and the waste types to be disposed in deep geological formations, depends on the existing and expected waste inventory and the possible host rocks available. A decision on a particular disposal concept has to be undertaken in accordance with national policies, current practices and regulatory frameworks. In [40], a decision for a disposal concept in The Netherlands is foreseen for 2100. Prior to that (2080), must be decided whether or not to aim for a multinational disposal facility. With respect to the potential disposal concept, one must be aware that in case a multinational solution is chosen and that repository would be situated in The Netherlands, a larger disposal facility is needed and the disposal concept will most probably differ from a concept for the national waste inventory only. Important in this context is also the fact that if a multinational solution will be realized earlier than the present national time schedule, the thermal impact of HLW might be larger than currently anticipated.

A decision concerning a host rock, e.g. one of the two potential host rocks currently considered in OPERA (rock salt and Boom Clay), can be based on several criteria, including safety, economic, logistic, and socio-political aspects.

### 3.2.3. Site selection

The next step after choosing a disposal concept will be the selection of a disposal site, according to [40] foreseen in 2115. *Site selection* (or *siting decision*) can comprise several steps. As in the selection of the disposal concept, for such a decision several criteria should be taken into account: safety aspects, geo-scientific and technical aspects, economic and logistic aspects, and socio-political aspects. Based on existing information, a first selection of regions can be made that fulfil general requirements of the repository design. Additional geotechnical characterisations can be performed in the candidate regions to support the suitability of these regions. Dependent on the disposal concept, the characteristics of the host rock can be more or less critical. Besides the use of remote techniques, boreholes can be drilled in order to acquire deep subsurface samples. Potential sites can then be narrowed down to community level. An alternative approach exists [49], based on which regions can mark their interest in hosting a disposal in an early stage, and after a pre-selection procedure, additional geotechnical work can be performed in order to support the suitability of a location.

### 3.2.4. Construction

Based on prior knowledge and collected information (repository design, safety case outcomes, site characterisation data, etc.), it can be decided to start up the construction process. Construction work should be performed on the basis of predefined qualifications that are part of a licence application, and evidence that requirements are met should be provided by the operator. Of importance here are the (local) properties of the host rock, which must fulfil the technical requirements on which the safety assessment is based and the long-term safety relies on. Requirements may be defined on the extent the host rock is getting affected by construction works.

If necessary, during construction some modification of the facility layout may be performed in order to anticipate local circumstances, e.g. heterogeneities of the host rock. Also certain aspects of design and/or material selection may be adapted to fulfil safety requirements. This may lead to re-assessment of license conditions. Another aspect of interest is to clarify the role of disposal monitoring or related activities such as the deployment of pilot or test facilities. These monitoring activities can be either part of the license application ("performance confirmation") or could be used to support a safety case

in general. Monitoring activities are initiated in this phase (or even earlier), and will support decision-making, mainly in the later steps, as discussed below.

### 3.2.5. Operation

The decision for starting the *operational phase* means, that radioactive waste is actually being disposed in the underground facility. It also includes all aspects of the transport, possible waste (re)packaging<sup>11</sup>, and emplacing of the waste packages. Such a decision can be supported by the submission of an updated safety case to the regulator that reflects the actual implementation of the disposal design and spatial properties of the host rock. The regulator decides to approve or disapprove operation, dependent on whether tests performed and site characterisation data collected so far are satisfactory, and the construction meets (predefined) requirements. It should be noted, that construction and waste emplacement can be performed simultaneously by separating the radiological controlled zones - where the waste is handled - from the part of the facility where construction works are taking place. Although this makes the decision point more complex (partial decisions), it can substantially shorten the operational period of the facility; for the OPERA reference concept, it is estimated that the waste emplacement process will proceed for more than a decade [48].

After waste emplacement, the underground access galleries can be kept open and (emplacement) equipment left in place for a certain period to facilitate retrievability of the waste packages.

### 3.2.6. Closure

The *closure* of a repository can be performed in a stepwise manner, i.e. after waste storage, disposal drifts are backfilled and sealed, and once a whole waste section has been completely filled, it can be backfilled and sealed by dams. Disposal galleries or sections of the repository may be backfilled and sealed while waste emplacement is still on-going in other parts of the disposal facility. After completion of waste emplacement, the disposal drifts and access galleries can be backfilled and closed while the shafts remain open. The stepwise closure of the disposal facility increases the operational safety and may be managerially beneficial in e.g. the case of flooding events, while still facilitating the retrievability of the waste.

To support monitoring and retrievability of the waste, however, it can also be decided to postpone the closure of the facility after waste emplacement is completed. The decision to close (sections of) the facility may influence the ability to monitor the evolution of repository components, because part of the monitoring equipment is no longer accessible [66], and in order to avoid impairment of the seals by wires, monitoring behind barriers must rely on autonomous energy supply and wireless data transmission techniques [64; p.21].

### 3.2.7. Post-closure

The *post-closure period* describes the situation when the facility is closed and the shafts are sealed and refilled. The repository will no longer need any maintenance or other human intervention, since all excavations have been backfilled and closed. Isolation of the waste fully depends on the passive safety properties of the repository.

As long as the surface facilities are maintained and/or monitoring data from the disposal facility is acquired, it is referred to as the *institutional control period*. During that period

<sup>11</sup> Surface-based waste-conditioning facilities, where e.g. HLW is repacked in the so-called "OPERA-supercontainer" [48]

the retrieval of the waste would still be possible, but unlike in the previous step, it would require costly drilling operations (e.g. cost estimation of shafts for a Dutch disposal concept: 150 - 675 million Euro [50]).

### 3.2.8. Post-licensing

At selected points in time it can be decided to either prolong or withdraw any further institutional control. This may depend on the public interest in prolonged control, and may also be influenced by the state of the monitoring equipment in the disposal. Another important aspect is the presence (or absence) of the specific know-how that is needed to be able to understand the meaning of monitoring results or the (scientific) arguments behind the long-term safety of the disposal facility. That knowledge might be weakening in time, while it is necessary to judge the implications of monitoring results if these are not in line with expectations.

At some moment in time, however, further institutional control is expected to be withdrawn. This is called the *post-licencing phase*, where the responsibility of the operator and regulatory authority ends. The decision of withdrawing institutional control thus implies that no operator and regulator are needed. This also means that any financial reservations that may have been held back in order to finance a potential retrieval operation of the waste<sup>12</sup> are not needed anymore.

<sup>12</sup> Which includes for example the building of an interim storage, the development/search of a new disposal concept/site and its construction

## 4. Retrievability, reversibility and staged closure

The concepts of retrievability, reversibility and staged closure has become ‘common sense’ in RWM in the last decade [51], because as discussed in the next section, these concepts address stakeholders’ and public concerns, at the same time allowing to deal with future uncertainties. The implementation of these concepts in a national RWM programme is expected to have a relevant beneficial influence in gaining societal acceptance, although it might be difficult to gain progress if decisions remain permanently open and responsive to changes in values, priorities and attitudes [52]. Furthermore, even though the implementation trajectory must be kept open to a certain extent, it is relevant to have at all times a clear outline of the principal process, its options, key issues to be considered, and potential risks. Therefore in this report an outline of a generic staged closure process for The Netherlands is developed and presented (Chapter 9).

Before coming to the set-up of the process itself, in the next section, some key ideas on ‘retrievability’, ‘reversibility’ and ‘staged closure’ are summarized<sup>13</sup>.

### 4.1. General concepts

Retrievability of the waste is an important requirement of the Dutch waste policy [19], and principles of reversibility and surveillance are already discussed in the VROM nota on radioactive waste from 1984 [18]. The principles of a stepwise approach are already introduced in Chapter 3. The next two subsections give a short summary on retrievability and reversibility. While reversibility, retrievability and staged closure seem conclusive and convincing high-level concepts, their implementation needs understanding of the complex scientific-technical limitations and their consequences for the overall process. One of the technical aspects related to this topic which came to light in the past decade is the role of monitoring in confidence building and decision-making. Basic principles and ideas on monitoring are summarized in Section 4.1.3.

#### 4.1.1. Views on retrievability

In 1998 - 1999, an EU Concerted Action was performed to provide a working definition of the term ‘retrievability’, to achieve a better understanding of its meaning and how it may be integrated in a disposal concept [53]. As working definition, ‘retrievability’ was seen as the *“ability provided by the repository system, to retrieve waste packages for whatever reason retrieval might be wanted.”* [53, p.21].

In [52, p.31], it is noted that retrievability

*“implies making provisions in order to allow retrieval should it be required [...]. Retrievability is a technical feature that facilitates the reversal of the decision to emplace waste in a repository”*

while in [54, p.11] it is stated that

*“Geological disposal, as currently envisaged in all national programmes, is in principle always a reversible technology. Even long after institutional oversight may have ended, and beyond the time when the integrity of waste containers can be assumed, waste recovery would still be possible, although it would be a major engineering endeavour that would require high resolve, resources and technology.”*

Retrievability can thus also be envisaged as a principal option that can always be considered, even after ‘Institutional oversight’ has ended. Finally, also retrieval of waste

<sup>13</sup>a more elaborated discussion can be found in separate RESTAC topic report [62]

can be considered from facilities that were not designed for that [55]. I.e., ‘retrievability’ is a rather conceptual term that gains its values from further clarifications of its purpose and extent.

When looking at key objectives for retrievability, the following list of potential reasons for retrieval can be found [53, p.19f]:

**Safety and operational arguments:**

- Disposal should be reversible in case something goes wrong with the emplacement of a package.
- Retrieval might be necessary in case a waste package malfunctions during or after emplacement.
- Retrieval might be necessary if the repository appears to be malfunctioning at a later stage.

**Licensing arguments:**

- Retrievability should be included in order to facilitate a staged decision and licensing process.

**Societal arguments:**

- Radioactive waste may contain potentially useful materials, which might become valuable in the future. It could be the wish of a future society to utilize such a resource.
- Disposal decisions should not be irrevocable, in order to provide future generations the option to take their own decisions.
- From a sustainable society viewpoint, high priority is given to reuse of materials and to minimize the quantity of waste that needs to be disposed. Views and/or technology for reuse of materials may be different in future.
- The precautionary approach and the recognition of uncertainty speak in favour of retrievability.

**Waste management arguments:**

- Future new technology or scientific knowledge could - based on re-evaluation of the cost/benefit balance - motivate modifications in earlier disposal, or retrieval of disposed waste packages.
- A repository that includes design features to keep the waste packages retrievable could offer better possibilities for control and surveillance of the waste after disposal.

**Public acceptance arguments:**

- A disposal concept might be better appreciated, when key decisions are reversible and when the waste is retrievable. Retrievability might enhance the acceptance of geological disposal.

In [54, p.11], in a more condensed manner, three main reasons for including retrievability in national programmes are observed:

- an attitude of humility or open-mindedness towards the future;
- provision of additional assurance of safety;
- to heed the desires of the public not to be locked into an “irreversible” situation.

#### 4.1.2. Views on reversibility

While ‘*retrievability*’ always contains a moment of ‘*reversibility*’ (but not the other way around), it makes sense to differentiate between ‘*reversibility*’ and ‘*retrievability*’ [56]:

*“Reversibility refers to decision-making during project implementation: it involves ensuring that the implementation process and technologies maintain flexibility so that, at any stage of the programme, reversal or modification of one*

or a series of previous decisions may be possible if needed, without excessive effort. A decision of partial backfilling, for example, may be made with reversibility in mind. Each major authorisation in repository implementation [...] can be seen as an assessment of whether the process can continue as foreseen or whether one of the reversibility options should be exercised [...]. Reversibility implies a willingness to question previous decisions and a culture that encourages such a questioning attitude. It also implies some degree of retrievability of waste.

**Retrievability** is the ability to retrieve emplaced waste or entire waste packages. While retrievability is an intrinsic part of the concept of waste storage, it is not part of the basic, long-term safety concept of waste disposal in a final repository. Waste should never be emplaced in a repository if the long-term safety case is not robust without reliance on retrievability. However, retrievability may still contribute to confidence in safety and retrieval may become desirable for non-safety reasons. Retrievability provisions may also provide additional flexibility during operation.”

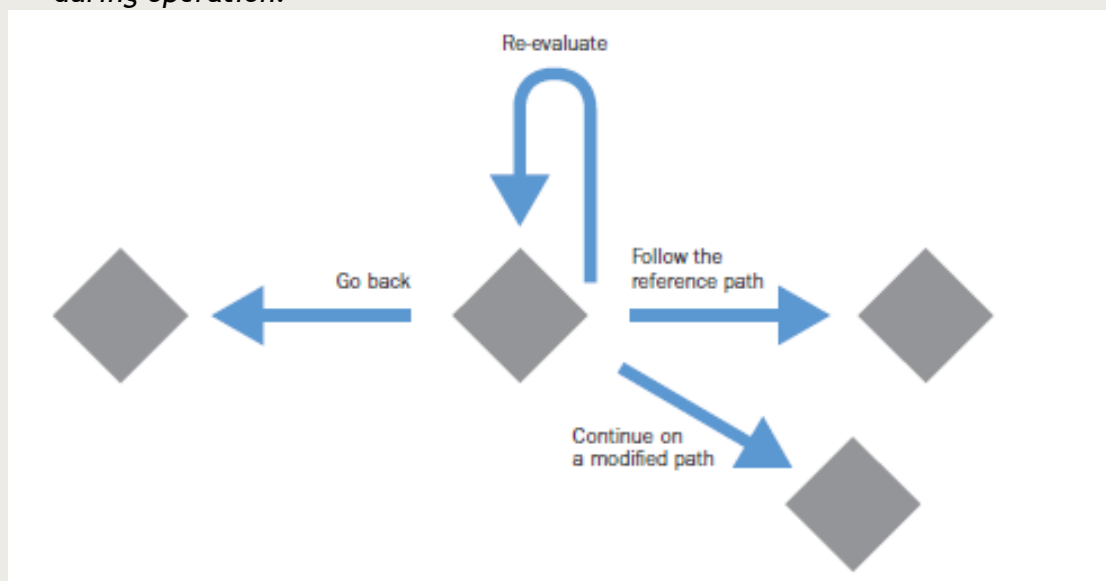


Figure 4-1: Reversibility in decision-making [57]

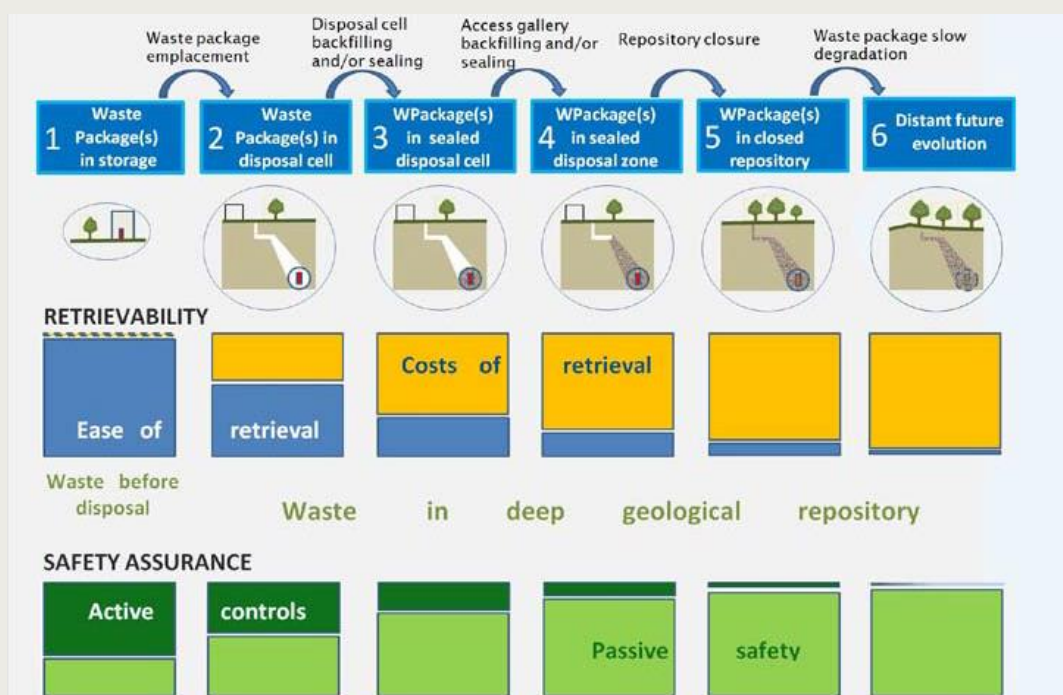
Reversibility is thus related to decision-making, and seen as an important tool for flexibility, because it provides the possibility to review a decision before going to a next step, to correct the decision if appropriate, and if necessary to change course. Reversibility is not always feasible for every decision making process. It can be applied, however, to a stepwise decision-making approach, and sends a message that (societal) stakeholders are not expected to accept and adjust to a *fait accompli* without opportunity to input their views or priorities. However, contrasting views on the meaning of ‘reversibility’ exists: in [58], it is noted that:

“‘Reversibility’ is just another concept that has generated heated debates. Some interpret reversibility as a means for facilitating the correction of potential mistakes in the future, which would imply that it primarily addresses uncertainty regarding the long-term safety of waste management facilities. Others, however, argue that reversibility draws on the positive connotation of flexibility and freedom of choice provided for future generations. According to this interpretation, reversibility represents a commitment to the values of intergenerational equity and democracy.”



The perspective of retrievability - as an instance of reversibility - implies that systems must be in place to understand, monitor and assess the performance of the disposal system. Retrievability provides reassurance that in case of error or of other necessity, humanity has some means of control over the emplaced waste [59]. Some concerns exist that the concept of reversibility and retrievability might create a false impression of safety: in [52, p.34] it is stated that reversibility and retrievability “*should not be used as programme features to divert the attention of civil society from the range of safety issues, nor to falsely reassure potential local hosts that their own hosting decisions are of little lasting consequence.*” There is also a general agreement that safety should not rely on human intervention, but should be *passive*, and that the primary intention of geological disposal is a permanent emplacement of the waste ([60], §2.d).

As part of the NEA ‘Reversibility & Retrievability’-project, a leaflet [58] was presented wherein a ‘retrievability scale’ was proposed, that illustrates qualitatively several aspects of retrievability, including the degree and type of effort that is needed to retrieve the waste in different stages of the disposal life cycle (**Figure 4-2**). The main message of **Figure 4-2** is that in course of time, the ease of retrieval is decreasing, and the costs of retrieval are increasing. The other message is the belief that finally, safety should not rely on active controls, e.g. the ability to monitor and retrieve the waste.



**Figure 4-2:** A retrievability scale for stakeholder dialogue [58]

#### 4.1.3. The role of monitoring, pilot facilities and URL's

Although the role of monitoring and its embedding in the safety case is still under development [61], a general agreement exists that the outcome of monitoring activities can provide relevant input to decision-making and thus supports the principles of reversibility, and staged closure. Monitoring can also be envisaged as a relevant element of the retrievability concept and the Dutch requirements of 'Isolation, Control and Surveillance' (IBC) [17, 18].



With respect to the role of monitoring in the implementation of a disposal, many monitoring activities are in some way related to ‘confidence building’ [62]. One important objective for monitoring is to comply with requirements of the regulator as part of the licence application (‘performance confirmation’), while other monitoring activities can be deployed to support the safety case in more general terms<sup>14</sup>, e.g. by demonstrating under *in-situ* conditions that relevant assumptions used safety analyses are valid.

While surface-based monitoring (e.g. groundwater, soil, and crops) can be implemented relatively straightforward, the potential role of *in-situ* monitoring of safety relevant features and properties of the host rock and the EBS<sup>15</sup> has its challenges. The monitoring of relevant process parameters inside a disposal facility is expected to contribute relevantly to the confidence in the safety [61], but when considering monitoring from technical point of view, one faces a number of potential limitations [63, 64]:

- In a disposal, properties of the EBS and host rock often evolve only slowly. In some cases monitoring during the operational phase only, i.e. between the emplacement of the waste and the closure of the facility might be too short to provide relevant information.
- Monitoring is expected to be performed in many cases behind safety relevant barriers, requiring either the use of non-intrusive techniques (e.g. tomography), or the use of wireless data transmission techniques. Although nowadays wireless techniques are used in a wide range of everyday applications, data transmission through geological rock material or EBS can be quite challenging. Furthermore, wireless monitoring equipment behind barriers need an autonomous power supply that can provide energy for the intended period of monitoring (several decades to centuries). Such technologies are currently not available in sufficient maturity [65].
- In many cases, sensors or others parts of the monitoring equipment cannot be accessed after placement. Therefore, durable monitoring solutions need to be developed and tested that meet the required performance in harsh environmental conditions over periods of several decades that might be necessary to collect sufficient evidence on the safety.
- Inaccessibility of sensors also complicates verification of the proper function of the monitoring equipment in case monitoring readings point to a potential impairment of the long-term safety. This imposes high demand on the reliability of the applied monitoring technology and the development of effective failure detection methods.

The above given limitations are generally acknowledged, and proposals have been made to overcome these [61, 63, 65, 66]. With respect to the slow evolution of the EBS and the host rock, one option is to prolong the period of the operational phase<sup>16</sup>, or to continue monitoring after partially or final closure<sup>17</sup>. Disadvantage here is that either the facility must kept open longer, with additional risks, or - in case monitoring is performed after closure - any corrective action as result of deviating monitoring results is obliged to high costs. Besides, availability of (wireless) monitoring technology that allows monitoring over decades is currently an important key topic in European research [67]. An alternative is the use of a ‘pilot facility’ or ‘test facility’ that is implemented early in the construction phase, in a separate part of the facility/host rock sufficiently removed from the main works during the operational phase. A pilot facility involves the emplacement of one or

<sup>14</sup> For a more detailed discussion see the RESTAC topic report [62]

<sup>15</sup> Engineered Barrier System

<sup>16</sup> by adding a *pre-closure* phase in which large parts of the facility are backfilled and sealed (see Section 9.1.4)

<sup>17</sup> When monitoring is used for decision-making, the time interval to monitor can also be closely related to the role retrievability has in a national RWM strategy.

several waste containers that will be retrieved after monitoring has ended, which will then be disposed of in the main facility. Such a pilot facility can be used to collect monitoring information under realistic conditions and on real scale, and has fewer restrictions with respect to the use of wired monitoring technology. It also allows to access the monitoring equipment for testing or (re)calibration of sensors during monitoring or afterwards. However, a pilot facility might include the temporary disposal of high-level waste (HLW) in the pilot facility before actual start of the operational phase, which might be a cause for concern for (local) stakeholders.

Demonstrating safety by monitoring can also be part of (research) activities in Underground Research Laboratories (URLs). URLs allow performing experimental testing and demonstration of relevant features of a disposal concept in an environment comparable to the one foreseen for the final disposal. URLs are used for experimental research in the early stages, which can often seamlessly ‘blend’ into *in-situ* demonstration activities of relevant features of a disposal concept in later stages. URLs could have a particular relevant role for the Dutch RWM programme, because the long-term interim storage foreseen in The Netherlands allows performing experiments over relevant time intervals, allowing collection of data on slow processes over long timespans preparatory to the disposal construction. However, because of the high costs of such a research facility and the rather small Dutch disposal programme, participation in existing URLs abroad, i.e. the *HADES* URL [68] in Boom Clay and/or rock salt facilities in Germany can be of particular interest. In a later stage, possibly after a decision on the host rock has been made, and focus shifts from experimental to demonstration works, it must be considered whether a national facility is needed and for what purposes.

#### 4.2. Synthesis

In the previous sections, general views on the principles of retrievability and reversibility are summarized, and relevant determinants and boundary conditions for the development of a staged closure process are elaborated. With basic principles of decision-making already reviewed in Chapter 3, in Chapter 9, an outline of a generic staged closure process in The Netherlands is given, based on the considerations discussed in the previous section, input from in-depth interviews performed with relevant national stakeholders and experts (Chapter 7), and discussion about key questions related to the implementation of the disposal process in a national stakeholder workshop (Chapter 8).

## 5. Involvement of Stakeholders

In the decision-making process towards long-term disposal of radioactive waste various stakeholders need to be involved to make sure their stakes are taken into account in the process. As pointed out in the Section 2.1, in RWM a broad agreement regarding the ethical, economic, and political appropriateness of a waste management solution, and a broad-based confidence in long-term safety and the organisational structures behind it are seen as key features of a successful implementation strategy. It was also noted that the communication and participation tools used as part of EIA are considered as inadequate for the complex and long-term process of the implementation of radioactive waste disposal.

With *confidence* and *trust*<sup>18</sup> as key concepts in current RWM, proper communication (and interaction) can be marked as an important aspect for successful implementation. Public acceptance is identified as one of the main challenges in implementing a national radioactive waste repository, even more relevant if a multinational facility is aimed at. An open and transparent decision-making process involving all stakeholders is seen as the only feasible way forward [12; p.60]; it is expected to increase confidence in the institutions, social support for decisions, and the integration of local knowledge [52; p.50]. While not expounded further in this report - the topic of communication with the general public is already addressed in the OPERA project *CIP* [39] - it can be noted that communication is an important cornerstone for a successful implementation of the RWM programme.

However, of particular interest for this report is the way stakeholders can be involved and can participate in the implementation process. With several radioactive waste management programmes rejected in the past, *stakeholder involvement*<sup>19</sup> has become a leading principle in radioactive waste management [52], and the related values of openness and flexibility are recognized by waste management organisations [69].

The topic of stakeholder involvement and participation has been given significant attention in the past two decades, resulting in the establishment of the Nuclear Energy Agency's (NEA) *Forum on Stakeholder Confidence* (FSC)<sup>20</sup> in 2000 to facilitate sharing of international experience in addressing the societal dimension of RWM [69]. The activities of the FSC and other initiatives have led to a significant number of reports on stakeholder involvement and participation (see [70]). The essence of the international experience and views on the topic of '*stakeholder involvement*' is summarized in the remainder of this chapter.

### 5.1. General definition of stakeholder and stakeholder groups

In the broad sociological sense, a stakeholder is '*someone involved in, affected by, knowledgeable of, or having relevant expertise or experience on the issue at stake*' [71]. This definition encompasses different types of actors, such as scientists, citizens, representatives from large companies, small entrepreneurs, policy makers, NGOs etcetera. In the most broad term, everybody can be envisaged as a stakeholder, e.g. as a taxpayer. It makes sense to distinguish different groups of stakeholders, based on their relation to the topic.

The need to engage stakeholders as representatives in decision-making is explained by Luhmann [72] from the notion of modern society as a selective arrangement of related

<sup>18</sup> '*confidence*' and '*trust*' are linked concepts, with *confidence* related to the decision-making process and *trust* related to institutions and their representatives [52]

<sup>19</sup> or '*dialogue*', see [52]

<sup>20</sup> <http://www.oecd-neo.org/rwm/fsc/links.html>

elements, aiming to reduce complexity. A number of ‘subsystems’ has emerged in society, such as the legal system, the political system, forming substructuring entities that organize social life around particular issues. These subsystems have grown slowly apart, developing their own rationality, framing of reality and language [73]. This continuing process of functional differentiation can lead to communicational ‘lock-ins’: in discussions about controversial risk issues such as nuclear energy or the disposal of radioactive waste, experts, decision-makers and laypeople are often unable to communicate in a meaningful way because they display different rationalities and speak different ‘languages’. While existing democratic institutions (such as the nation state) tend to lose their influence, the process of individualisation delivers more freedom of choice and self-determination for individuals. This creates a greater necessity for transparency and negotiation. Laermans [74] concluded that negotiation - including stakeholder engagement - has become the lead model for decision-making in modern society.

A ‘stakeholder’ in the context of RWM is defined as [52, p.17]:

*“any actor - institution, group or individual - with an interest or a role to play in the radioactive waste management process”.*

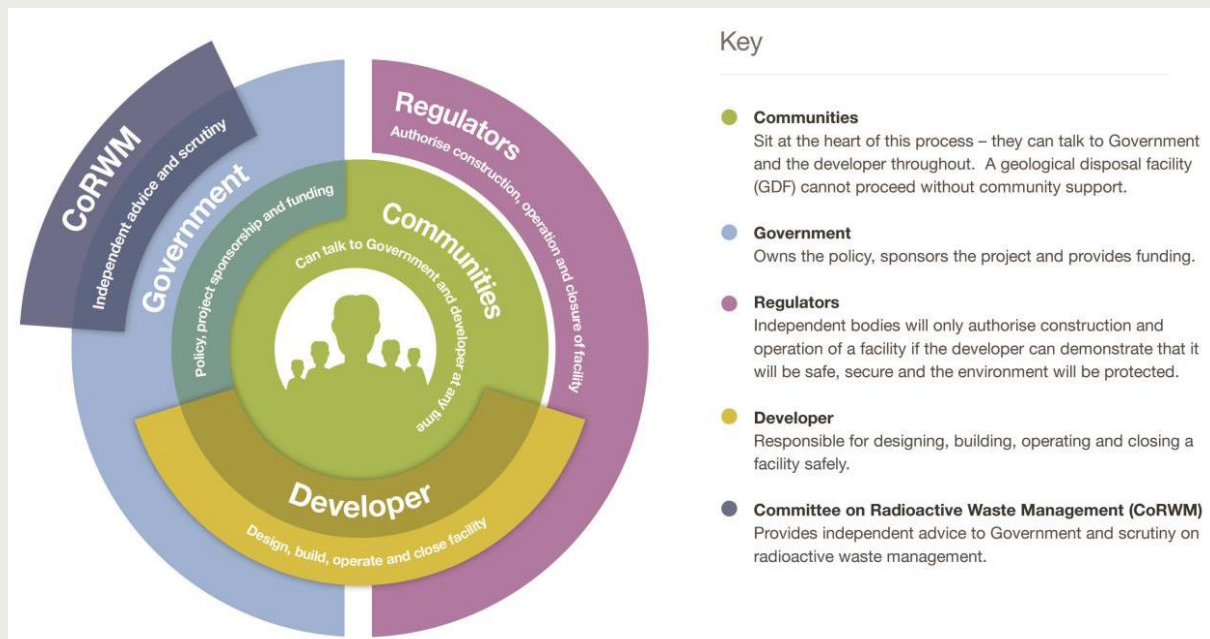
General groups of stakeholders that have been identified in RWM includes *policy-makers, safety authorities*<sup>21</sup>, *scientific experts & consultants, implementing agencies, potential host communities, elected local or regional representatives, and waste generators* [52]<sup>22</sup>. More elaborated stakeholder analyses distinguish between the *general public, demographic groups* (like young people), *residents, representatives or elected officials of local communities; national and regional government, ministries, or departments, regulators, national and local NGOs, local pressure groups* (that could be either for or against a given project), *trade unions, the media, the scientific research community, implementing organisations, the nuclear industry, contractors, waste generators, and international organisations* [88; p.47]. In case a disposal facility is close to a national border, the neighbouring country should be accounted as stakeholder, too [12; p.10]. It should also be noted that organisations can have several stakes.

Some discussions exist on whether the *safety authority* should be regarded as a stakeholder, because the *safety authority’s* role is seen as neutrally applying rules and standards. However, the FSC majority view is that the *safety authority* has a role to play and therefore, can be considered a stakeholder [52; p.50].

The number of stakeholders becomes greater over the course of decision-making processes, and the type of stakeholders involved depends on the stage in the process [52]. Likewise, the decisions to be made and the responsible organisation can change in the course of the implementation. Of particular relevance here is to distinguish between national and *local stakeholder*, i.e. members of the local community that volunteer for hosting the disposal facility and their legal representatives. Local stakeholders come into the picture once a siting decision is prepared, but are difficult to address in earlier stages. Often the term “*local partnership*” is utilized to emphasize the specific quality of public involvement in decision-making in a host community, and the constructive two-way communication that should be aimed at [52].

<sup>21</sup> elsewhere also indicated as ‘regulator’ or ‘regulatory body’

<sup>22</sup> the stakeholders ‘policy-makers’, ‘safety authorities’, and ‘implementing agencies’ are equivalent to respectively the ‘government’, ‘regulator’, and ‘operator’ discussed in Section 2.1.



**Figure 5-1:** Example of suggested roles and responsibilities of stakeholder [75]

An alternative approach to group stakeholders is presented in [76], based on the different perspectives of actors on decisions and their outcomes:

- **Risk losers:** those who may be adversely affected by an environmental risk decision, in terms of their health, economic, or social well-being, and possibly their deeply held values;
- **Risk gainers:** those who may be favourably affected by an environmental risk decision, typically through economic gains;
- **Risk perpetrators:** those who ‘create’ the risk;
- **Risk managers:** those responsible for preventing or minimising the risk.

Like in the aforementioned classification, these categories are not mutually exclusive: e.g. a risk loser may also be a gainer through new employment opportunities. The division in such categories emphasize that stakeholders are likely to have not only very different perspectives but it is argued that they also have different abilities to participate, depending on spatial and temporal dimensions (**Table 5-1**):

- in case of *localized and long-term risks* that extend far into the future, stakeholders can be only partially represented because stakeholders that must deal with the consequences of the current decision process cannot be involved;
- in case of *diffuse and long-term risks*, losers and gainers are not only numerous and scattered, most are even not born yet. The longevity of the risk means that their successors will inherit the consequences of past decisions without having had the opportunity to “weigh in” on those decisions.



**Table 5-1: Possibility of stakeholder participation in environmental-risk decisions [76; p.101]**

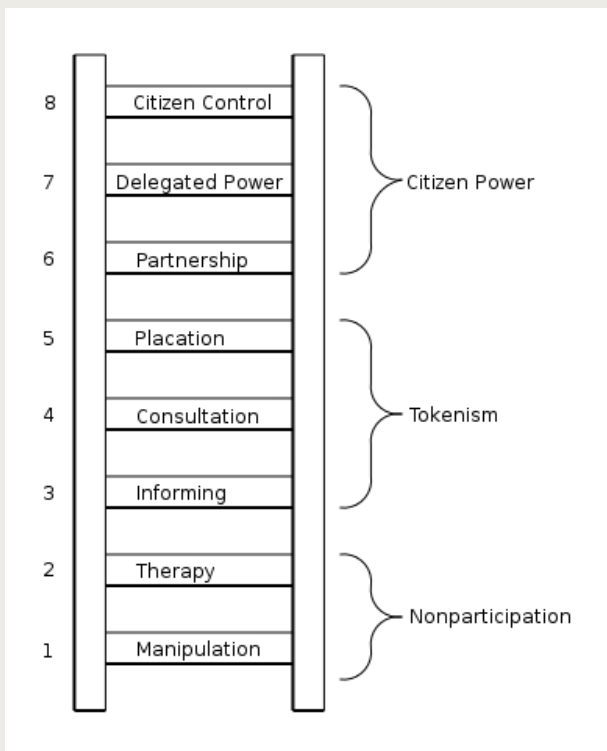
Risk Category	Type of Stakeholder			
	<i>Losers</i>	<i>Gainners</i>	<i>Perpetrators</i>	<i>Managers</i>
1. <i>Local and short-term</i>	Yes	Yes	Yes	Yes
2. <i>Local and long-term</i>	Partially	Partially	Partially	Partially
3. <i>Diffuse and short-term</i>	Minimally	Minimally	Partially	Partially
4. <i>Diffuse and long-term</i>	Very minimally	Very minimally	Very partially	Very partially

### 5.2. Intensity of stakeholder participation

Minimum requirements on stakeholder participation are implemented in many European countries as results of the *Aarhus* and *Espoo conventions* [77 , 78], and regulates the principles of free access to information, basic rules on public participation in decision-making and the access to review procedures before a court of law, e.g. as part of EIA regulations.

#### Arnstein's ladder of participation

However, as argued before, more far-reaching involvement of stakeholders are aimed at in RWM. When discussing the degree of participation that should be aimed at, often Arnstein's '*ladder of participation*' is applied, that distinguishes eight rungs of participation ranging from '*non-participation*' over '*degrees of tokenism*' to '*degrees of citizen power*' [113 ].



**Figure 5-2: Level of participation [113]**

This differentiation in intensity of stakeholder involvement in the process has been adapted and used over the years in all sorts of stakeholder processes. An adapted version of this participation ladder was also used as an underlying principle in the stakeholder workshop (see 8.3.1).

Arnstein describes the various levels of participation and at the same time discusses the way they can be used or misused.

Obviously the '*non-participation*' levels are not really meant to create a level of involvement, but are merely an expression of power through position and knowledge. In a sensible stakeholder process these variants should not be considered as they are meant to enforce stakeholders to 'deal with it' rather than take them seriously. The '*therapy*' level is basically an intervention after the fact, i.e. to learn to cope with decisions already taken, but that is beyond the scope of this study.

On the levels of '*tokenism*', '*informing*' means that to some extent stakeholders are taken seriously as they are considered to be able to understand and respond to information presented to them by experts. However, '*informing*' is a one way street. Experts on the issue at hand tend to overestimate the effect of information as they are immersed in the issue, and others are not. Also, the aspect of interpretation and filtering of information by the audience based on fears or anxieties is often missed in the process which may lead to unexpected opposition. A more detailed discussion on these communication-related aspects in the context of RWM can be found in [39].

'*Consultation*' and '*Placation*' (placing representatives in a consulting board) are steps towards more stakeholder involvement. '*Consultation*' refers to the receiving end of the informing process. It means generating responses to information provided, though no actual guarantee is provided that this feedback will be utilised in the decision-making process. '*Placation*' offers this opportunity to a delegation of the stakeholder community. Here, the edge is the mandate and involvement of this delegation in the decision-making process. Its effectiveness depends on the strength of the link between the representatives and their constituency.

'*Partnership*', '*Delegated power*' and even '*Citizen control*', in this case stakeholder control, are the most intensive levels of stakeholder involvement. Obviously, as they increase the level of involvement and commitment from stakeholders, they also reduce the level of control over the process and its outcome. Non-aligned interests and different weight attribution to risks and effects may lead to outcomes that, though highly valued by stakeholders, are less acceptable to experts.

The level of involvement is not a fixed state during the implementation process. In the early stages of RWM there will be more questions than answers. The decision range is still wide and the level of involvement will probably be low. *Informing* and *consulting* will then probably be enough to keep the most interested and involved stakeholders aligned. In time, it is expected that decisions are made that limit the scope of options and the final outcome will become clearer. This will generate interest and also the request by more stakeholders to become involved in the decision-making process, although the range of options has become smaller. As Arnstein puts it: '*"nobodies" in several arenas are trying to become "somebodies" with enough power to make target institutions responsive...*' [113]. This will generate tension at both the experts and those already involved in the preceding phases. A key moment in the implementation process that will lead to such an increased interest in participation and new stakeholders is the siting decision.

### **Strength and weaknesses of stakeholder interaction**

The Arnstein model as discussed above also illustrates the strengths and weaknesses of the various levels of stakeholder interaction intensity. In [79], strength and weaknesses of a participatory approach are discussed (Table 5-2), arguing that the distinction may be



useful when it comes to making sense of how the public perceives the legitimacy of the decision-making process.

**Table 5-2:** Overview of the strengths and weaknesses of the two major contending normative theories of democracy (adapted from [79; p.58])

Democratic theory	Strengths	Weaknesses
Pluralism	<ul style="list-style-type: none"> <li>• Builds upon personal relationships among stakeholders</li> <li>• Efficient</li> <li>• Develops competent political actors</li> </ul>	<ul style="list-style-type: none"> <li>• Produces a club of political experts who can become isolated from the general public</li> <li>• Does not contribute to the political maturation of citizens</li> </ul>
Participatory democracy	<ul style="list-style-type: none"> <li>• Develops skills of citizenship in all people</li> <li>• Maturation of the individual</li> </ul>	<ul style="list-style-type: none"> <li>• Time consuming</li> <li>• Requires broadly educated public</li> <li>• Potential for emotional decisions</li> </ul>

In general, participation in decision-making creates involvement and commitment, if done properly. Key is the intent and quality of the process. Is there a genuine interest in stakeholder interest and will there be room for influence? Quality also refers to careful identification of relevant stakeholders and balancing the interests to avoid opposition bias. The backside of participation is the management of expectations. The more room for influence, the higher the expectations that participation will actually lead to influence on the outcome, which may not always be possible from expert point of view [80].

#### Transparency of decision-making and dialogue with stakeholders

The degree of stakeholder involvement in RWM can differ with respect to different national contexts, the current state of the disposal programme and the national history of RWM. Two key concepts with respect to stakeholder involvement in RWM, on which exists broad agreement, are *transparency in decision-making* and *dialogue* with the stakeholder.

*Transparency* or access to information is seen as a first important step of involvement and is expected as an important way to achieve confidence and trust. According to the FSC [52; p.58], this includes that:

- *Stakeholders must have access to understandable information about what is happening and why.*
- *Both technical soundness and procedural fairness are important for decision-making processes. Transparency assures that technical soundness and procedural fairness are visible and verifiable.*
- *Stakeholder confidence is never established “once and for all”. Transparency allows confidence to be earned on a continuous basis.*

The FSC has identified three elements that are paramount to transparency in decision-making, as summarized in Table 5-3.

**Table 5-3: Transparency and decision-making (adapted from [52; p.58])**

<b>Process</b>	Procedures and plans for making decisions should be designed to be visible, iterative, and flexible
<b>Structure</b>	Clear roles and responsibilities must be assigned to involved actors and their interdependencies made visible
<b>Behaviour</b>	Individuals and institutions must demonstrate core values: be open, transparent and willing to involve others. Transparency is more than just a formal application of rules. A certain degree of informality is also allowed

In [34], it is also emphasized that for gaining confidence, it is important that all stakeholders understand what is to be broadly *achieved* at each step of decision-making, and on what would be required in terms of information and confidence in order to do so.

*Dialogue* with the stakeholder is considered as important aspect of stakeholder involvement, defined as [52; p.13]:

*“...an approach of collaboration or partnership between the institutional actors and the affected communities essentially, involving public participation in the decision-making process and mutual learning. Dialogue is one of the conditions to enhance trust in and credibility in the decision-making process.”*

#### **Evolving role of stakeholders**

Table 5-4 gives a summarizing overview of the evolving roles of stakeholder groups in RWM, reflecting an increased degree of involvement of the different groups. However, differences in approaches were noticed, too [69; p.10]:

*“One group of the organisations focuses primarily on informing the public in the interest of increasing transparency of, and familiarity with, their activity. A second group, besides increased transparency, also aims at carrying on a dialogue with stakeholders, addressing their needs and concerns and taking them into consideration in decision-making.”*

**Table 5-4: Evolving roles and responsibilities of different stakeholders [81]**

Stakeholders	Traditional expectations for roles and responsibilities	Evolving expectations for roles and responsibilities
Policy-makers	<ul style="list-style-type: none"> <li>Defining policy options, investigating their consequences under different assumptions, making policy choices.</li> </ul>	<ul style="list-style-type: none"> <li>Informing and consulting stakeholders about policy options, assumptions, anticipated consequences, values and preferences.</li> <li>Setting the “ground rules” for the decision-making processes.</li> <li>Communicating the bases of policy decisions.</li> </ul>
Nuclear safety regulator	<ul style="list-style-type: none"> <li>Defining regulatory requirements and guidance.</li> <li>Defining a regulatory process, making choices regarding regulatory options.</li> <li>Reviewing the implementer’s safety options and design and asking for possible complements or modifications. Making decision on the step forward.</li> <li>Reviewing and validating operational rules.</li> <li>Controlling the compliance of operation with operational rules.</li> <li>Communicating the bases of regulatory decisions.</li> </ul>	<ul style="list-style-type: none"> <li>Maintaining open and impartial regulatory processes.</li> <li>Providing stakeholders with understandable explanations of the mechanisms of regulatory oversight and decision-making, including explanations of the opportunities available for stakeholder participation therein.</li> <li>Serving as a source of information and expert views for local communities.</li> </ul>
Scientific experts, consultants	<ul style="list-style-type: none"> <li>Carrying out scientific/technical investigations with integrity and independence.</li> <li>Advising institutional bodies such as the nuclear safety regulator, other authorities and implementing agencies on technical issues in relation with safety concerns in view of providing balanced and qualified input for decision-making.</li> </ul>	<ul style="list-style-type: none"> <li>Acting as technical intermediaries between the general public and the decision makers within the limits of the mandate that they have received from the organization upon which they depend.</li> <li>Providing balanced and qualified input for all stakeholders and encouraging informed and comparative judgement.</li> </ul>
Implementing agencies	<ul style="list-style-type: none"> <li>Proposing safety options and designs for radioactive waste management solutions, investigating their consequences under different assumptions.</li> <li>Developing a chosen solution, implementing the solution.</li> </ul>	<ul style="list-style-type: none"> <li>Co-operating with local communities in working through proposed options and designs in order to find an acceptable project for radioactive waste management.</li> <li>Co-operating with local communities in implementing the project.</li> <li>Interacting with policy-makers and regulators.</li> </ul>
Potential host communities	<ul style="list-style-type: none"> <li>Accepting or rejecting the proposed facility.</li> </ul>	<ul style="list-style-type: none"> <li>Negotiating with implementers to find locally acceptable solutions for radioactive waste management that help avoid or minimise potentially negative impacts and provide for local development, local control, and partnership.</li> <li>Interacting with policy-makers and regulators.</li> </ul>
Elected local or regional representatives	<ul style="list-style-type: none"> <li>Representing their constituencies in debates on radioactive waste management facilities.</li> </ul>	<ul style="list-style-type: none"> <li>Mediating between several levels of governments, institutions and local communities in seeking mutually acceptable solutions.</li> <li>Interacting with regulators and implementers.</li> </ul>

### 5.3. Methods of stakeholder involvement

When implementing stakeholder involvement, it needs to be understood that different stakeholders have different perspectives, perceptions, beliefs, interests and values [52; p.13] and thus may require different approaches. Tools for stakeholder involvement have been developed in several European projects (e.g. *CiP*<sup>23</sup> [82], *OBRA* [83], *ARGONA* [84], *RISCOM II* [85], *IPPA* [86]). An overview of possible tools and techniques for stakeholder involvement can be found in [87].

<sup>23</sup> as distinguished from the OPERA project CIP

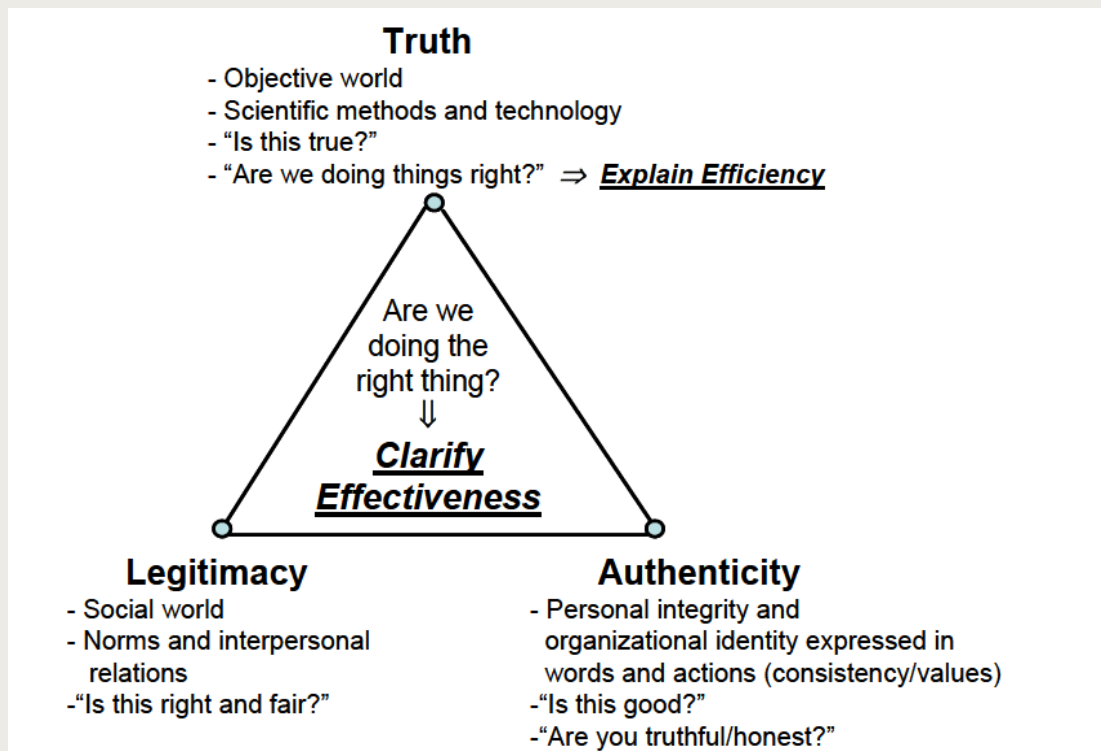


Figure 5-3: The RISCUM model: decision-making interpreted as communicative action [85]

Three general key factors for successful interactions are outlined in [88; p.35]:

- *"an open, transparent, fair and participatory decision-making process. This should be decided on a national level, and national actors must demonstrate commitment to the process;*
- *clear roles and responsibilities for different actors including local authorities;*
- *main actors' behaviour reflecting values like openness, consistency, desire for dialogue, as well as demonstrating technical competence."*

Furthermore, it is stated that:

- Stakeholders should be allowed to participate from the very early stages of a siting process;
- Public interest in participation can be maintained only if stakeholders believe that they can have an influence on key decisions;
- Information on management options and alternatives is needed to create a balanced deliberation.

In the European project *CiP* (Community Waste Management In Practice), guidelines for constructing '*inclusive governance*' are given [89; p.9ff], including:

- Consider that local, regional and national stakeholders each have legitimate interests and input;
- Help the full range of players come together to generate agreements;
- Organize public involvement with the goal of improving decisions;

- Empower stakeholders, particularly local players, to make meaningful decisions and influence other decision makers at each successive phase in facility siting, operation and beyond;
- Consider that local stakeholders are a vital resource for vigilance and for safety over the generations;
- Adapt deadlines so that local players have time to develop competent input;
- Ensure legal status and material resources for local competence building;
- Involve players in agreeing on criteria for going forward or backing up in a stepwise process;
- Preserve the capacity of future generations to influence decision-making on RWM.

Several examples of ‘successful’ interactions with respect to siting are reported (e.g. from the US [90], Sweden [91] and Finland [92]), however, it is unclear to what extent such experiences may be transferred to the Dutch context. Part of the success may be based on unique features of local political culture, greater trust to governmental organisations in general, the absence of ‘burdens from the past’, lower population density, the abundance of the host rock in large parts of the country, and other factors. In [93; p.55] it is emphasized that

*“A geologic repository programme unfolds in a broad societal context. Every repository programme acknowledges that stakeholder involvement and consultation are keys to the success of a project that is long-term and expensive undertaking and presents potentially substantial societal risks. Each country has its own societal and political context and, therefore, stakeholder interaction has different meanings and methods in different countries.”*

In [52; p.50], it is noted that legal provisions defining stakeholder interactions are helpful for a number of reasons:

- They provide a formal framework for stakeholder involvement and provide opportunities for participation. In addition, for the recognised stakeholders the possibility of appealing against decisions that do not comply with the legal provisions is also guaranteed.
- They give arguments in favour of stakeholder involvement when decision makers resist involving certain groups or organisations in the decision-making process.

It is further noted in [52; p.50], that

*“Any rule that actually restricts the participation of citizens has the potential to be counterproductive, because in principle, in a complex world everybody can be a stakeholder, at least in an indirect way (e.g. as a taxpayer). People or organisations should be entitled to decide if they want to participate, or to select their own representatives.”*

However, in [70; p.9], workshop participants agreed that in the field of stakeholder involvement a proper combination of formal and informal elements is needed, reflecting the phase attained by the decision-making process: in earlier phases when many issues are open, everybody can be recognised as a legitimate stakeholder, and stakeholders involvement should be managed in a flexible and informal way. In later phases when decisions are to be made, well defined rules are needed for integrating divergent views.

It is recommended in [52; p.51] that stakeholders should be involved as early as possible in the implementation process. While it may be necessary to elaborate the specific details of the participation process during the course of the implementation process, informal consultation and involvement processes can be successful in early phases.

The long duration of the implementation process, not only of relevance for the Dutch situation, requires that stakeholder generations will be replaced. This raises the challenge of how to supply information and knowledge to new generations. However, some fundamental discussions are expected to be repeated as new generations or stakeholders enter the scene [52; p.51].

#### *5.4. Organisational aspects of stakeholder involvement*

As discussed in the previous sections, active participation of and dialogue with stakeholders are generally recommended. Both activities are not self-supporting, but need an organizational setting that allows to deploy such activities. This section will discuss aspects of the organisational structure and elaborates requirements for an organisation to be able to effectively manage long-term stakeholder involvement in RWM.

##### **General considerations**

One of the main concerns in organizing a stakeholder processes is to arrange a process that does attract the stakeholders. This is particularly the case for The Netherlands, where the actual disposal is not foreseen before 2100. A step-by-step approach with a clear and specific action plan for the next phase keeps stakeholders involved in that phase with a higher commitment. On the long term, external factors also become less predictable which prohibits concrete planning. Therefore, stakeholder activities or projects to be planned and completed should cover a limited time span over a foreseeable future, e.g. 5 years.

Step-by-step also means that it is possible, and therefore even mandatory, to integrate feedback loops from the past. What went according to plan, and what did not? How and what can we learn from that analysis for the next phase? How can we avoid running into the same pitfalls again? This is facilitated by having a regular evaluation moment in the process with all concerned stakeholders in an open and transparent fashion. The stakeholders involved may vary throughout the process; this is facilitated by the step-by-step approach. Furthermore, in course of time, perceptions and interests of stakeholder may change.

A stakeholder process may therefore be split into manageable segments with very specific evaluation procedures in between. The time span of the segments may vary, and may be synchronized with reviews/updates of the safety case, and the design of the process should ideally be part of a stakeholder process in itself.

##### **Organisational responsibilities**

In [15], responsibilities with respect to the organization of stakeholder interactions are defined:

- The *government* defines the overall process, the processes for decision-making and the involvement of interested parties. It sets clearly defined legal, technical and financial responsibilities for organizations, establishes and maintains an appropriate governmental, legal and regulatory framework, and secures financial and other resources.
- The *regulatory* body has to develop regulatory requirements specific to each type of disposal facility for radioactive waste, and has to engage in dialogue with waste generators, the operators of the disposal facility and interested parties to ensure that the regulatory requirements are appropriate and practicable.



- The *operator* of a disposal facility for radioactive waste is responsible for developing and maintaining a safety case, on the basis of which decisions on the development, operation and closure of the disposal facility have to be made.

### Organisational aspects

The organisational aspects of stakeholder engagement have been a topic over the years. In [52] the organisational setting of a stepwise decision-making process is characterized by the following ten overall features:

- **Independence:** The notion of independence addresses the question of institutional setting to start with. The process of stepwise decision-making over a long period of time as sketched above will need a continuous basis, hence a stable institutional setting. As already elaborated in [39], trust in the responsible organisation is an important aspect. Obviously, any institution committed to a specific outcome of the process or leaning towards a constituency of specific interests will be unmasked as biased and not independent. In [7; p.64] it is recommended that the national WMO should remain independent of any initiatives linked to the development of nuclear technology, in order to maintain a high level of trust and credibility. Currently, the responsible operator and WMO in The Netherlands is COVRA, and the responsible regulator is the ANVS.

The above definition of independence refers to the way an organisation or a group of people managing the stakeholder process are connected, committed to or involved in the outcome of the stakeholder process: the more committed, the less trustworthy for stakeholders.

As independence in the RWM is considered to be important from a safety point of view the concept of independence from the process outcome may interfere with the concept of independence, or rather the split of responsibilities in dealing with regulatory, hence safety issues as illustrated in the IAEA ‘classical triangle’ (Figure 2-1). Obviously, any outcome of the RWM stakeholder process will have to meet the scrutiny of the three independent corners of the triangle. This may limit the scope of options to be discussed with stakeholders, which may make stakeholder management more complicated as will be discussed below: the less options, the less room to deal with stakes involved, and the more likely opposition will occur. It will be important in the stakeholder process to use this triangle to illustrate and also define the room to manoeuvre as well as the three independent roles involved.

This probably makes the independence of the actual stakeholder managing agent even more important: if the stakeholder process is managed by either one of them, or on behalf of one of them, stakeholders may feel that they are pressed into a corner already decided by these independent roles. The effect of cornering stakeholders is creating opposition and a complex process.

- **Clarity of role and ownership:** Clarity of role and ownership is defined by the mandate within which the process of stepwise decision-making takes place. Ownership in the context of managing the stakeholder process means that the managing organisation has a clear mandate for action, hence ‘owns’ the problem of realizing a proper process leading to broadly accepted decision-making. Clarity of role and ownership therefore requires a clear assignment given to any institution that is made responsible for managing this stakeholder process. It has to be clear what the role and mandate is of this institution. This includes several levels:
  - Value level: what level of involvement is to be achieved, stakeholder identification and involvement;

- Process level: setting up a stepwise decision-making process, monitoring and evaluating the process;
  - Organisation level: organisational aspects such as experts involved, methodologies applied, data management, reporting etc.;
  - Responsibilities and boundaries of mandate: level of authority and autonomy.
- **Dedicated and sufficient funding**: The stepwise approach to the stakeholder process can facilitate continuous and sufficient funding by agreeing that budgetary agreements will be part of the regular evaluation process for each stage. Dedicated and sufficient funding sets requirements for designing the process in a cost-effective and efficient way, and serves as safeguard for continuity.
  - **A non-profit status**: This criterion is fair and logical from the perspective that the dialogue process should not be driven by a commercial interest in any specific outcome.
  - **Commitment to retaining a highly devoted and motivated staff**: The effectiveness of stakeholder processes requires capable staff on both content and process. The long term and the complexity of the process will require keeping focus and dedication. Selection of staff should therefore be taken seriously and any underperformance should be dealt with. ‘Trust is easy to loose and hard to regain’ applies especially to stakeholder processes. Staff devoted and motivated to keep all interests aboard and have a keen eye for missing interests may be decisive in the success of the process.  
When recruiting or assigning staff to this stepwise process, it may be wise to commit them to more or less completed decision cycles, or at least one full stage. This will make sure they are not only committed to set up a part of the process but also feel responsible for completing the process they started successfully.
  - **Structural learning capacity**: The concept of a stepwise approach in long-term processes includes two elements:
    - The long-term aspect of the process, where decision-making will be up to more than one generation, requires a well-documented decision-making system that allows arguments to be recovered and re-evaluated;
    - The stepwise aspect in regularly reviewed stages requires that decisions are well evaluated and lessons are learned and applied to the consecutive stages.

The essence of the learning process however is not only documenting the process, but facilitating a learning process that contributes to a common understanding of all aspects involved. *“The concern is not to ‘win the argument’, but to advance understanding and human well-being. Agreement cannot be imposed, but rests on common conviction”* [94]. An effective way of organizational learning can be achieved through the integration of stakeholder interests into organisational planning: trust is not merely an objective of stakeholder involvement, but also a means of sustaining stakeholder integration, which helps organisations implement a learning culture [69; p.8].

- **An internal culture of “scepticism” allowing practices and beliefs to be reviewed**: One of the main concerns in long-term decision-making processes is the lack of interest of sceptics in participating in the process [17]. Conceptual debates and general conclusions do not attract as much attention as short-term, concrete decisions. Apart from the dilemma of getting stakeholders involved and committed, the effect of this may be that only the positively involved stakeholders will ‘run the show’ and decisions may be insufficiently challenged by sceptical viewpoints.  
A way to overcome this is to actively engage sceptical views as an explicit role. Also, the organisational culture in the overall stakeholder process should explicitly support sceptical viewpoints.

- **High levels of skill and competence in relevant areas:** The responsible staff should have the ability to communicate with all sorts of stakeholders. Aspects such as emphatic ability and responsiveness towards sceptical views should be weighted as heavily as the technical expertise in the various disciplines of radioactive waste management. These elements should be taken into account when recruiting staff members to ensure a balanced portfolio of expertise and abilities.
- **Strong internal relations and cohesion:** Solutions to complex and controversial issues such as managing radioactive waste will from time to time be faced with strong debate. This requires strong internal relations and cohesion within the responsible organisation to guide the debate and prevent the process to be hijacked by a specific interest. This means clear operational rules and open communication.
- **Ethical charter or code of conduct:** Organizing stakeholder processes on delicate issues such as RWM requires a basis of trust and respect for opinions, interests and fears. This sets requirements for the principles under which the managing organisation operates, i.e. its code of conduct. A code of conduct is defined as the *'Principles, values, standards, or rules of behavior that guide the decisions, procedures and systems of an organisation'*. They refer to aspects such as integrity, professionalism, honesty and respect. The core of this code of conduct would be that all stakeholders are to be treated with equal respect and involvement, irrespective of their interests and backgrounds.

## 6. Stakeholder inventory

In this chapter, the method for the stakeholder inventory is described. Two organizing principles underlie the stakeholder inventory performed: stakeholder affiliation (6.1) and stakeholder discourses (6.2).

### 6.1. Stakeholder affiliations

As a first step towards stakeholder engagement, a mapping of the stakeholder force field in the process toward political decision-making for geological disposal was performed. The force field analysis started with an inventory of relevant stakeholder groups in The Netherlands. As long-term radioactive waste management is currently not a widely discussed issue in The Netherlands, only a small group of stakeholders from outside the technical arena are currently actively involved in research projects and debates about geological disposal, and the overview given below is therefore mainly based on literature review rather than identified interest in the subject. **Table 6-1** contains a selection of relevant stakeholder groups or organisations that have been identified in The Netherlands. The table is based on the general groups distinguished in RWM (see Section 5.1), and includes the responsible actors identified in Section 2.1)<sup>24</sup>. This selection is ordered by (1) the common division of stakeholder (Role) in the “democratic triangle” [95], and (2) clusters relevant to RWM. Additional to the individual stakeholder summarized in **Table 6-1**, stakeholder groups exist, representing several of the stakeholders listed. Of interest here are *The Netherlands Nuclear Society* (NNS) and the *NORA* platform that took the initiative for the OPERA research programme [96].

It is important to note that this list neither is, nor aims to be, a complete overview of each and every stakeholder that can be identified as influential. Firstly, possible local stakeholders have not been included since the present discussion does not involve siting. Secondly, we have restricted the scope to Dutch stakeholders which means that parties potentially influential to the Dutch research programme such as e.g. IGD-TP, NIRAS<sup>25</sup> or water boards close to a national border are not included. Thirdly, considering the long timespan of the decision-making trajectory and the uncertainty of future societal dynamics, pinpointing existing organisations and institutions may not succeed as an organizing principle to map the stakeholder force field regarding radioactive waste management issues over several decades. Many existing institutions, NGOs and civil society organisations may not outlive the coming century, and other types of organisations may evolve.

The stakeholders mentioned in **Table 6-1** should be regarded as examples of different roles and types of stakes present in the stakeholder force field. Over such a long term, however, stakeholder discourses rather than their actual affiliation are stable elements [97]. Therefore, additional to the stakeholder inventory summarized in **Table 6-1**, in the next section focus is directed to the discourses underlying stakeholder views, values, considerations and opinions. **Figure 6-1** summarizes the responsible stakeholders according to the “classical” IAEA triangle (see Section 2.1 and **Figure 2-1**) and their interactions.

<sup>24</sup> Note that in **Table 6-1** the actors ‘government’, ‘regulator’, and ‘operator’ are described with respect to their roles respectively as ‘National policy’, ‘implementing organisation’, and ‘Safety authority’.

<sup>25</sup> Belgian National Agency for Radioactive Waste and enriched Fissile Material (Dutch: Nationale Instelling voor Radioactief Afval en verrijkte Splijtstoffen)

**Table 6-1: Inventory of current stakeholder organisations in The Netherlands**

<b>Role</b>	<b>Cluster</b>	<b>Stakeholder organisation(s)</b>
<b>State</b>	National policy	Government and RWM-related ministries
	Regional and local policy authorities	Interprovincial consultation (IPO), Association of Dutch municipalities (VNG), water boards, provinces, municipalities, Unie van Waterschappen
	Implementing organisation	COVRA
	Safety authority	Autoriteit Nucleaire Veiligheid en Stralingsbescherming (ANVS)
	Advisory bodies	Wetenschappelijke Raad voor Regeringsbeleid (WRR), Instituut Voor Milieuvraagstukken (IVM), Rijksinstituut voor Volksgezondheid en Milieu (RIVM), Raad voor Volksgezondheid, Raad voor de Leefomgeving en Infrastructuur (RLI), Sociaal-Economische Raad (SER)
<b>Market</b>	Waste generators/owners	EPZ (ElectriciteitsProduktiemaatschappij Zuid-Nederland), NRG, ECN, Delft University of Technology, Urenco, hospitals
	Related industry & services	Vewin, Water supply companies, LTO Nederland (Dutch Federation of Agriculture and Horticulture), construction companies
	Public services	Expertisenetwerk bodem en ondergrond
<b>Civil society</b>	Research organisations	NWO (The Netherlands Organisation for Scientific Research), universities (e.g. Delft University of Technology, University of Utrecht), research institutes (TNO, NRG, ECN, Deltares), unaffiliated advisors/experts, Rathenau instituut, Nederlandse Vereniging voor stralingshygiëne (NVS)
	NGOs	World Information Service on Energy (WISE), Landelijk Kernenergie archief (LAKA), Greenpeace, Natuurmonumenten, Milieudefensie, World Wide Fund for Nature (WWF), local resistance groups
	Other	churches, cultural and tourist organisations, labour unions

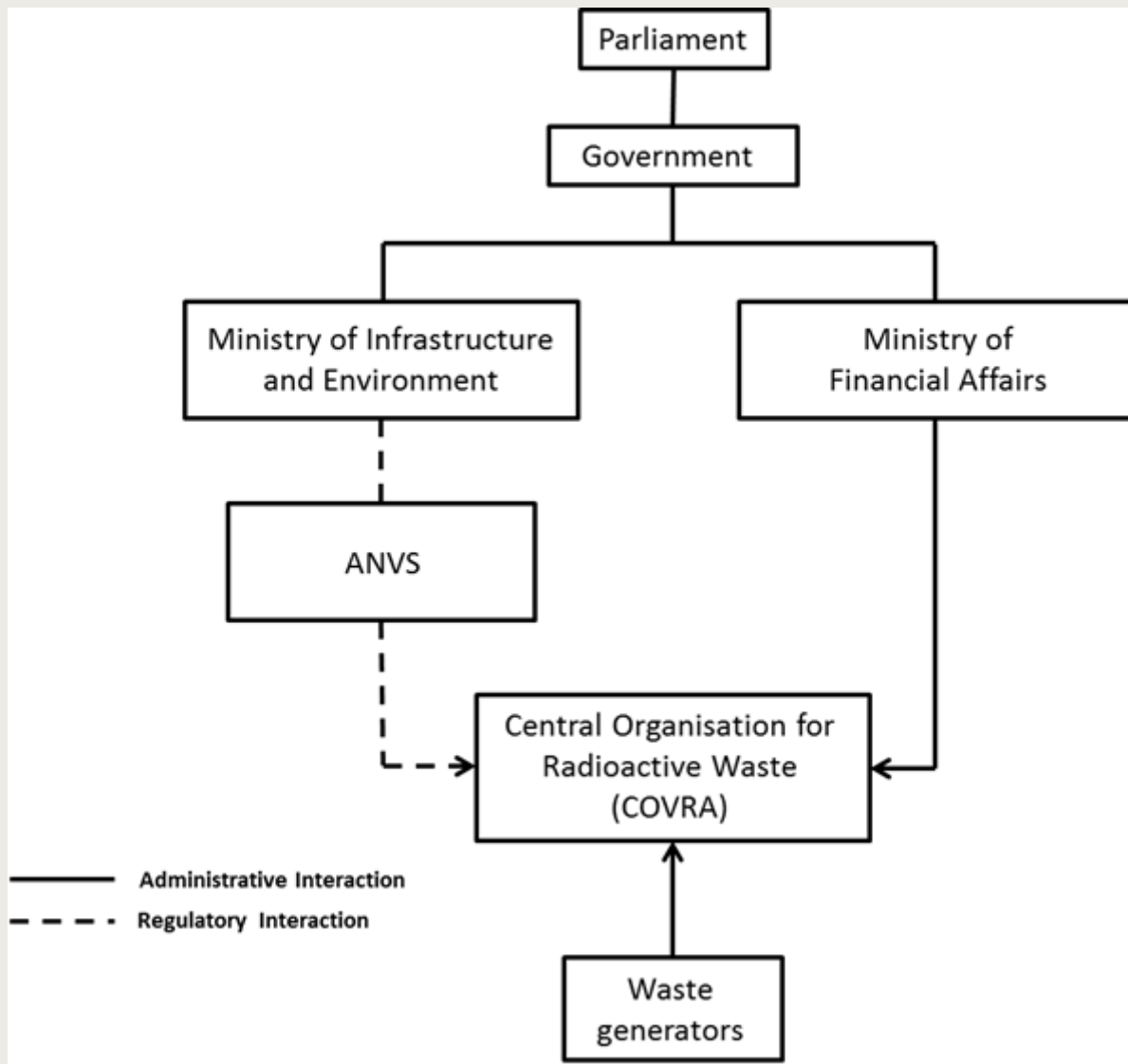


Figure 6-1: RWM responsible institutions' map of The Netherlands, adapted from [98]

### 6.2. Stakeholder discourses

Regarding relevant norms and values in RWM, in 1995 IAEA provided 9 fundamental principles of radioactive waste management [9], already summarized in Chapter 2. A closer look to these principals reveals that all principles are linked to societal norms and values:

- **Principle 1 - Protection of Human Health:** Radioactive waste shall be managed in such a way as to secure an acceptable level of protection for human health.
- **Principle 2 - Protection of the environment:** Radioactive waste shall be managed in such a way as to provide an acceptable level of protection of the environment.
- **Principle 3 - Protection beyond national borders:** Radioactive waste shall be managed in such a way as to assure that possible effects on human health and the environment beyond national borders will be taken into account.
- **Principle 4 - Protection of future generations:** Radioactive waste shall be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today.
- **Principle 5 - Burdens on future generations:** Radioactive waste shall be managed in such a way that will not impose undue burdens on future generations.



- **Principle 6 - National legal framework:** Radioactive waste shall be managed within an appropriate national legal framework including clear allocation of responsibilities and provision for independent regulatory functions.
- **Principle 7 - Control of radioactive waste generation:** Generation of radioactive waste shall be kept to the minimum practicable.
- **Principle 8 - Radioactive waste generation and management interdependencies:** Interdependencies among all steps in radioactive waste generation and management shall be appropriately taken into account.
- **Principle 9 - Safety of facilities:** The safety of facilities for radioactive waste management shall be appropriately assured during their lifetime.

The underlined texts in these 9 principles demonstrate that while the content is of technical and scientific nature, all include clear socio-technical considerations. What is “acceptable”, what is “appropriate”, and what constitutes “undue burdens” is a matter of societal agreement that can be informed, but not determined, by estimates and calculations of possible effects and predicted impacts to the best of current scientific knowledge. The RWM community has been aware of this for the past decades, the 9 principles appear straightforward, and few stakeholders would counter argue their significance. However, when it comes to defining terms such as “acceptable” or “appropriate” it is important to realize that these definitions are subject to debate as well as changes over time, sometimes even within one generation, and that different stakeholder groups are in favour of different definitions and have different priorities. We will illustrate this by referring to the term ‘discourse’.

A *discourse* can be defined as a coherent way of seeing and talking about an issue. Discourses relate to how an individual, or a group of actors, in particular circumstances and at a particular time, relates to and forms conceptions of certain matters [99].

The (public) debate about RWM can be seen as an arena in which a battle between discourses takes place. In this battle, stakeholders can attribute views and opinions to one-another and they may disqualify actors to make statements from a certain discourse. In Cotton [100], for example, the ‘citizen involvement’ discourse promotes a central role for citizens in participation and decision-making since they have relevant (local) expertise and points of views in addition to those of government and scientists. However, this is defied in the ‘technocratic’ discourse, which states that decision-making is best left to government and scientists, as citizens are lacking the relevant knowledge needed for decision-making. This example clarifies that the definition of ‘relevant knowledge’ may differ per discourse.

Within the force field of long-term RWM, a breakdown of stakeholder discourses thus provides an additional level to analyse or look upon stakeholders than the more ‘traditional’ grouping given in **Table 6-1**. It also helps to overcome the practical problem of ‘non-response’, i.e. the fact that although a broad range of potential stakeholders was identified in Section 6.1, it was to be expected that only few of them would be available for the interviews and workshops performed as part of this project. In the next section, stakeholder discourses as identified in empirical research in the UK are elaborated in more detail in order to support the selection of individuals and stakeholder representatives in the empirical research performed in this project (Section 7.2 and Chapter 8).

### *6.3.Example of RWM stakeholder discourses in the UK*

To assess radioactive waste management options in the UK, the Committee on Radioactive Waste Management (CoRWM) started with ‘a blank sheet of paper’, enabling non-technical and non-industry actors to provide input into the assessment process. Since this project aimed for a similar type of input from stakeholders but an extensive investigation of discourses in The Netherlands with a sufficient large number of respondents was judged to

be infeasible, a study of Cotton [100] is used to (1) obtain an idea of what discourses on RWM may look like, and (2) guide the selection of respondents for in-depth interviews (see 6.2) to aim for broad representation of discourses. While it was judged impossible within the scope of this project to systematically verify whether these discourses are also present in The Netherlands, still the outcome is useful guiding principle for the practical implementation of interviews and workshops.

To render subjective opinions open to analysis in order to identify a number of ‘idealized discourses’, Cotton [100] made a selection from a range of written and verbal statements intended to provide a breadth of personal and institutional perspectives. His sources included primary data from interview and focus group sources taken from previous social scientific studies and stakeholder workshops as well as excerpts from newspaper articles, academic literature on radioactive waste management, press releases, political speeches, technical and scientific literature, NGO publications, statements by religious organisations, online environmental philosophy discussion groups and political party manifestos. Next, he had the statements ranked by 12 research participants representing ‘citizen stakeholders’ and 12 research participants drawn from the former British radioactive waste management organisation Nirex. Based on this ranking, he computed seven statistically significant factors, representing seven distinct discourses (Factor A - the ‘citizen involvement account’ - being the strongest in terms of explanation of variance, and Factor G - ‘the final stewardship account’ being the weakest). Each discourse is focusing on different concerns about radioactive waste management. The seven accounts are presented as narratives, composed from statements drawn directly from the data, but they are in themselves selective interpretations, based upon the factor scores. Below are one-sentence summaries of the seven discourses. For full explanations of each discourse we refer to Cotton [100].

- A. The ‘citizen involvement’ account:  
*Equal influence and acknowledgment of each perspective*
- B. The ‘holistic’ multinational account:  
*Trust and fairness in distribution of costs and benefits*
- C. The ‘technocratic’ account:  
*Leave it to policy makers and scientists*
- D. The ‘anti-nuclear’ account:  
*Nuclear scientists cannot be trusted and must be controlled*
- E. The ‘risk governance’ account:  
*Foster openness and dialogue to ensure proper risk management*
- F. The ‘final disposal’ account  
*Deep geological disposal in our own country is the best option*
- G. The ‘stewardship’ account  
*Trans generational and transnational issues must be considered carefully.*

## 7. In-depth interviews

In this chapter, the objectives, method, results and conclusions of the in-depth interviews are described.

### 7.1. Objectives

A series of exploratory in-depth interviews was conducted with a selected group of stakeholders. The primary objective of these interviews was (a) to discuss key uncertainties related to RWM and (b) to discuss their considerations regarding both the short-term and the long-term decision-making process.

### 7.2. Methodology

From a long list of representatives of current stakeholder organisations (based on the stakeholder inventory depicted in **Table 6-1**), a selection was made to identify possible respondents for the in-depth interviews. The selection of interviewees focussed on the extent to which these were expected to be able to contribute to an inventory of key uncertainties and considerations regarding RWM rather than covering the whole spectrum of stakeholders. The following selection criteria have been applied:

1. Spread between the (expected) discourses regarding RWM;
2. Ability to discuss uncertainties of RWM;
3. Willingness to discuss long-term RWM;
4. Availability and accessibility.

Based on these criteria, 14 people were invited to take part in a one-to-one in-depth interview. An information leaflet was supplied to each of them, containing information about the project and the aim of the interview, as well as factual information about RWM (Appendix 3). It was underscored that the interview data would be treated confidentially, i.e. respondent names would not be made public and the project report would not contain direct citations.

A semi-structured interview protocol (in Dutch, Appendix 2) was developed for the in-depth interviews. All interviews were conducted face-to-face at the interviewee's premises (in most cases in their office; some interviews took place elsewhere, for instance at the interviewee's home). All interviews lasted at least one hour, but the average length of the conversations was approximately 90 minutes.

After a brief introduction of the project, three main questions were introduced:

- What will final disposal look like in The Netherlands in the next century?
- Under what conditions would a final repository in The Netherlands be acceptable?
- Which key uncertainties to these conditions can be identified?

The following topics were then discussed, not necessarily in fixed order:

- Acceptability of geological final disposal;
- Long-term perspective, key uncertainties to decision-making;
- International cooperation;
- Ethical issues;
- How to organize decision-making and participation.

A draft interview report was made of each conversation which all interviewees received for approval and to correct any misinterpretations. Once approved, the interview reports (10 in total) were subject of a qualitative content analysis, in which a distinction was made between:

- The most important uncertainties categorized by the PEST method: Political, Economic, Social, and Technical uncertainties;
- Ethical aspects of decision-making;
- Procedural aspects of decision-making.

Each statement from the interviews was coded as either a political, economic, social, technical, legal or environmental aspect. Sub codes within these categories were used to distinguish between various dimensions within the category. For example, social aspects could refer to either short-term or long-term developments in societal dynamics. The systematic approach to the content analysis and the resulting typology of respondents' statements is included, in Dutch, in Appendix 4.

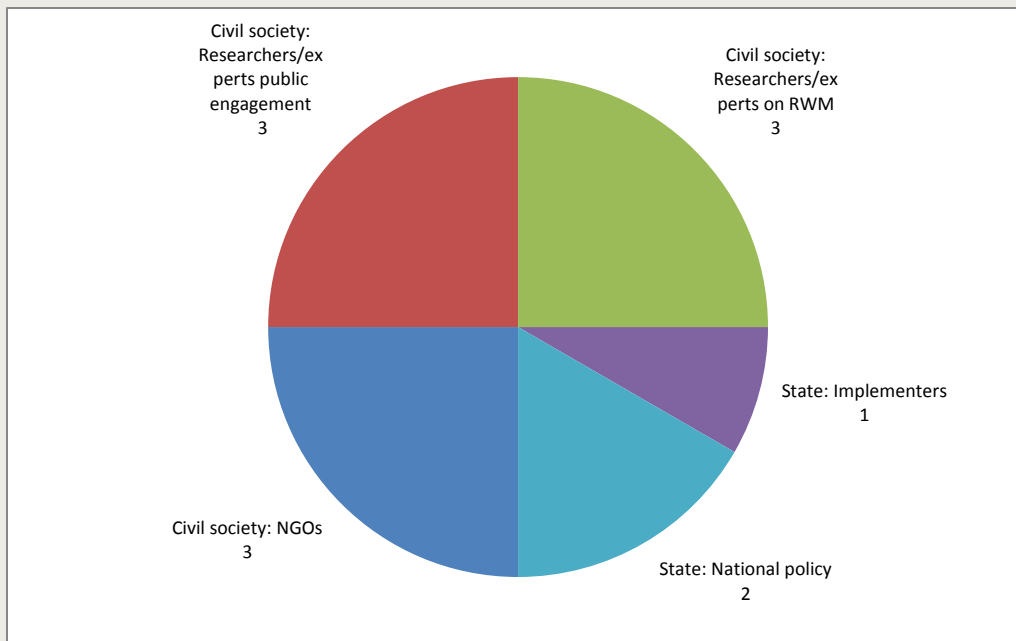
### *7.3. Results*

#### **7.3.1. Respondents**

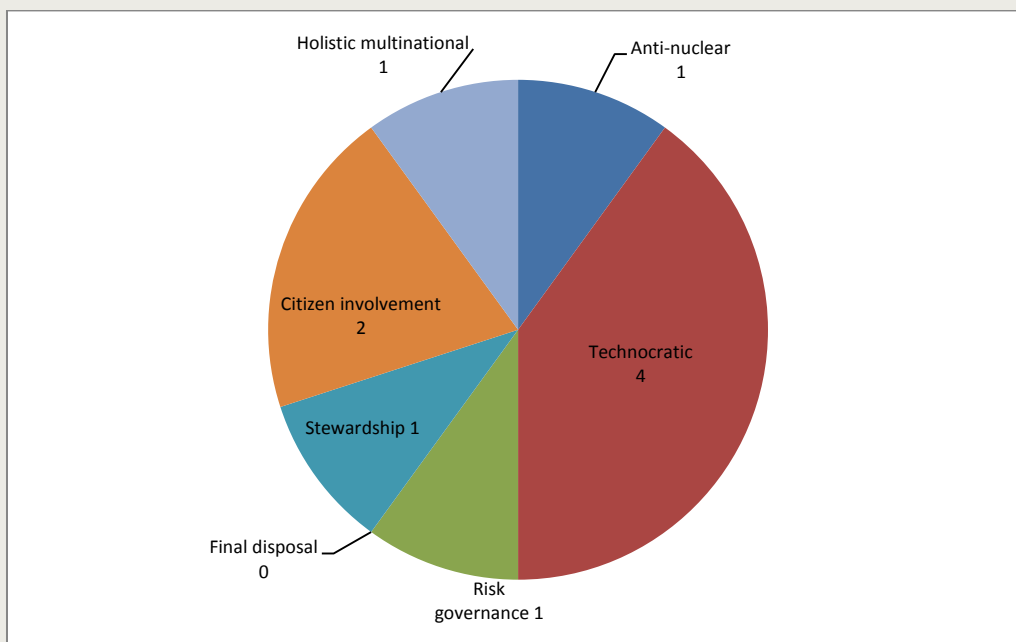
Eleven respondents responded positively to the interview request, from which two people suggested to participate together with a colleague (double interview) arguing that this person had important complementary views. This resulted in 13 participants. Three people rejected: one due to lack of time, one due to a perceived lack of involvement in the topic, and one because there was no remuneration available.

One respondent insisted on answering the interview questions by e-mail. However, this did not result in usable results, so this interview was excluded from further analysis. Finally, 10 interviews, with 12 people, were used for further analysis.

**Figure 7-1** displays the respondents for the in-depth interviews by affiliation. Each interview was classified as dominantly representing one of the discourses discerned by Cotton (see section 6.3). In some cases, it was quite clear which discourse best reflected the conversation, but in other cases two or even three different discourses appeared to fit. In those cases, an expert judgment was made in order to classify the respective conversation as exemplary of a particular discourse. **Figure 7-2** displays the interviews by discourse. It shows that despite the limited number of interviews, a wide range of discourses was captured.



**Figure 7-1: Interview respondents by stakeholder affiliation (n = 12)**



**Figure 7-2: Assessment of similarities of the discourses in the UK (Cotton [100]) with the interviews (n = 10, two double interviews)**

The following subsections discuss each of the five aspects central to the interviews:

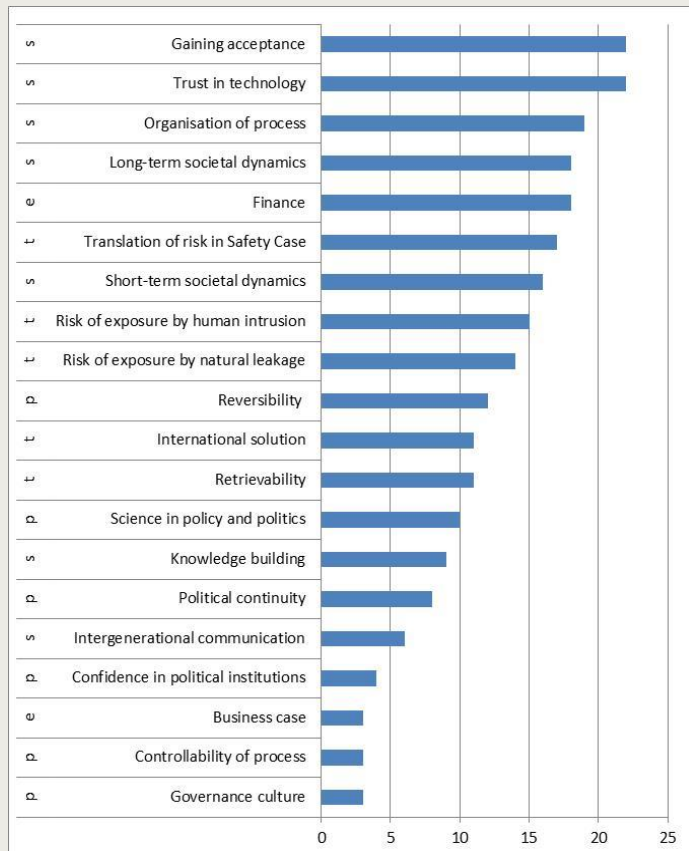
- Acceptability of geological disposal as final solution;
- Long-term perspective, key uncertainties to decision-making;
- International cooperation;
- Ethical issues;
- How to organize decision-making and participation.

### 7.3.2. Acceptability of geological disposal as final solution

Though interviewees were purposely given room to disagree with the current consensus on geological disposal as the best option with the current knowledge, they had no problem accepting this view as the starting point of the discussion. However, some did mention that there are other possible solutions for RWM that should be taken into consideration. Several interviewees furthermore agree that the basic notion should be to reduce the amount of high-level waste to a minimum with all technological solutions available (transmutation, for example). Two interviewees find it difficult to involve themselves in a discussion about geological disposal as long as the amount of waste continues to increase through the production of nuclear energy. Finally, about half of the interviewees at some point admitted to think that the problem of RWM is so complex that no adequate solutions may exist at all. They displayed a high sensitivity to the complexity of the matter and a sense of distrust towards those expressing high certainty about the ‘right’ solution and manageability of its implementation.

### 7.3.3. Long-term perspective, key uncertainties for decision-making

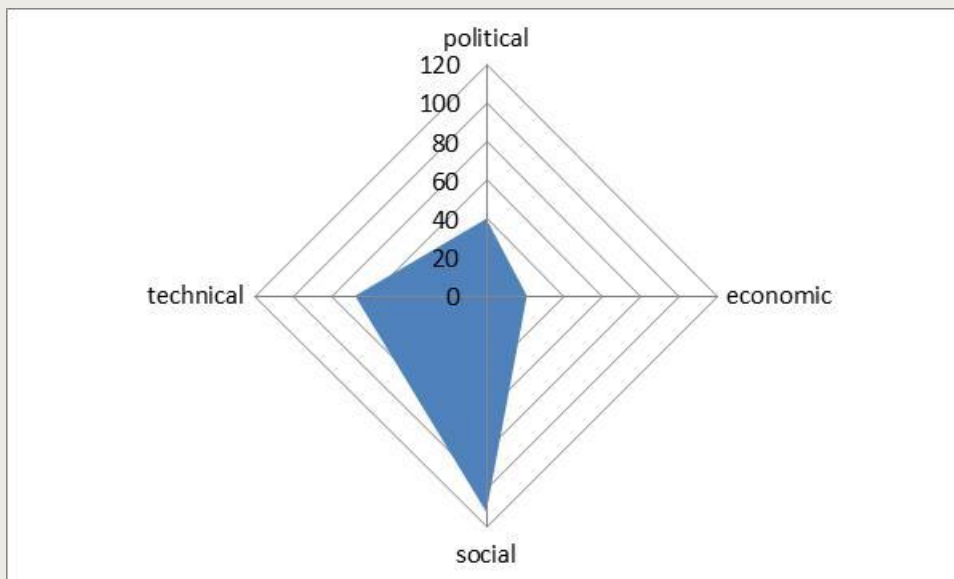
**Figure 7-3** shows the frequency with which key political (p), economic (e), social (s) and technological (t) aspects were mentioned in the interviews. The reason for analyzing frequencies is that the number of times a topic comes up can be an indicator of its importance in the discussions with the respondents. However, it should be noted that this analysis only reflects how often particular uncertainties have been discussed in the interviews. It does not show in how many interviews the particular uncertainty was mentioned and whether it has been discussed from a positive or negative viewpoint. As such, the overview is only meant to give an impression of most discussed issues among this group of respondents. The remainder of this paragraph summarizes the most salient findings and how these were discussed by the interviewees.



**Figure 7-3: Number of quotes per PEST aspect**



As Figure 7-3 shows, the top-4 of most discussed uncertainties is of a social nature: gaining acceptance, trust in technology, organisation of the process, and long-term societal dynamics. The fifth uncertainty is the economic aspect of finance. Figure 7-4 displays this more clearly by clustering aspects on the 4 PEST dimensions.



**Figure 7-4:** Clusters of PEST aspects with total number of mentions

Regarding acceptance, some interviewees state that the main challenge is to explain the risks of geological final disposal to a lay public in an understandable way. In contrast, other interviewees state that the main challenge to acceptance is to establish two-way communication or process mediation, in which actors acknowledge that the public has valuable knowledge about for example (local) historical, social, institutional, cultural, or ethical aspects that can be of relevance to the demonstration or implementation of technical solutions.

Regarding trust in technology, some interviewees display confidence in the view that we can rely on technology to solve our problems. They state that to the best of our present (scientific) knowledge, geological disposal is the preferred solution. Risks of this solution can be mapped with acceptable reliability. For this group, technology is not the main uncertainty because - from their perspective - it is relatively controllable compared to societal dynamics. Instead, they state that socio-cultural factors will be main predictors of technology acceptability. Other interviewees agree on this view, but not on its cause. Whereas to some the main challenge is to explain the matter to non-experts, others tend to display a sense of distrust towards strong statements of technological and procedural certainty and the tendency to 'explain' to others what they hold as truisms. Some interviewees argue that technological uncertainties exist and should be admitted. They state that over such a long term, models have very little predictive value and we are unlikely to have found the best technological solution yet. However, views converge at the statement that more investments are needed in (independent) research. Many interviewees agree that the insight that geological disposal is the best solution is relatively recent and may be subject to change. Mistakes have been made in the recent past, for example in Germany (Asse II), so it is thinkable that mistakes will be made in the future leading to a change in preferred solutions.

About organisation of the process (towards siting), interviewees mainly questioned whether and how this could be done properly. As long as the designated site is unknown, it may turn out difficult to get and to keep people involved. There are several examples of

extensive public engagement, for instance in Belgium, but the question is for how long will the results of such extensive public consultation remain valid when decision-making fails? Related to short-term societal dynamics, several interviewees also raised the question whether and how to involve stakeholders who oppose the use of nuclear technology. Some pointed out that such stakeholders should be involved anyhow in order not to end up in a stalemate. But others argued that if opponents have been given ample opportunities to involve themselves and they still refuse, there is little to be done. For example, some NGOs disagree with the current decoupling of the discussion of RWM and the discussion of nuclear energy. Should this principle be changed, or are there other ways? Some interviewees argued that generally, opportunities for conflict management and mediation should be incorporated in the decision-making process already at an early stage.

The uncertainty “Long-term societal dynamics” refers primarily to the question whether future generations will be smarter and more peaceful or, in contrast, be more violent and more ignorant of the dangers of radioactive waste. Related, it refers to changing views on technology, changes in value orientation (individualist or collectivist), and changes in the societal relations between science, politics, and citizens. Given these uncertainties, several interviewees indicate that decisions may best be based on certain societal values that tend to be relatively stable over time, regardless political shifts.

Interviewees discussed the economic uncertainty of financing the disposal facility. Some tend to regard finance as secured, the state providing backing. Others express doubts about the possibility to build up and maintaining sufficient resources in time. The logic of developing an international solution is also linked to this aspect. Countries can save up faster or slower depending on the amount of waste; from this perspective it would make sense for The Netherlands to seek cooperation with other countries with low amounts of waste.

Regarding technical uncertainties, risk of exposure to radiation as a result of either natural leakage or human intrusion was addressed at least once in each interview. Some interviewees with a technical background in RWM linked the risk of leakage by human intrusion or natural leakage to the safety case. Interviewees from other backgrounds questioned whether such long-term uncertainties could ever be modelled reliably.

Finally, regarding political uncertainties, the main topic of discussion was the question whether postponing a decision to start the process towards siting in The Netherlands is positive or negative. On the one hand, a risk of postponement is loss of momentum. One interviewee stated that over the past 30 years, similar research has been performed over and over in approximately 5-year cycles. On the other hand, it was acknowledged that having more time might lead to better quality decisions. It was also stressed, by most interviewees, that decision-making should always be reversible; a “no-regret” policy should be followed.

Retrievability also came to the table in the interviews (ranked 12<sup>th</sup> in **Figure 7-3**). Two main arguments in favour of retrievability were identified. Firstly, retrievability is necessary, even at high costs, to enable the correction of miscalculations and mistakes such as the situation in Asse II. Secondly, retrievability is necessary to enable future generations to find another solution. Two arguments against retrievability are higher costs and the risks of having an open mine imposed by ill-willing or ignorant people.

#### 7.3.4. International cooperation

**National borders have no meaning from a geological or historical point of view.** Generally, interviewees tend to agree that waste should be stored in the geologically more suitable locations. Overall, it makes sense to the interviewees that building fewer geological

disposal locations reduces risks, though implications for waste transport should also be considered. There are, however, moral considerations that rise questions about transnational solutions. Some interviewees discuss moral aspects of multinational solutions to RWM (international equity), in line with principle 3 in the 1995 IAEA guideline [9]. Translation of this principle into measurable or at least objectifiable concepts is complicated. What do we mean by ‘acceptable level of protection’ for human health and environment? How can it be assured that possible effects on human health and the environment beyond national borders will be taken into account? And can economic incentives be used in such a way that it does not lead to immoral effects, for example poor countries accepting waste for national economic reasons while local populations may suffer? Other ethical issues are discussed in the next paragraph.

### 7.3.5. Ethical issues

Four ethical aspects were brought up in the interviews. Intergenerational equity was brought up at least once in all interviews, acceptability and collective responsibility in half of the interviews, and international equity in about one third of the interviews.

Intergenerational equity is by far the most discussed ethical issue in the interviews. Most interviewees underscore that the problem of RWM should be solved by the generations who have caused the problem. Two main challenges to this issue are identified.

Firstly, intergenerational equity was discussed in relation to risks of natural leakage. In one interview, the problem of calculating acceptable exposure risks for future generations was discussed at length. It was noted that the definition of what is acceptable is less straightforward than it seems, because it implies (a) consensus on what is acceptable today and (b) availability of a reliable method for calculating long-term impacts. An ethical conflict may arise between what ‘we’ consider to be acceptable for the present generation and what this implies in terms of acceptability for future generations. Can it be argued that yet unborn generations also have to bear part of the burden since they too profit from the wealth that nuclear technology has generated? If so, to what extents do they profit compared to other generations? And what does it mean to guarantee intergenerational equity institutionally? One interviewee points out that the longest surviving institution we know to date is the Catholic Church, which is less than 2000 years old - and the Dutch constitutional law is only 150 years old.

Secondly, intergenerational equity was discussed in relation to Principle 5 of the IAEA guideline [9], stating that “radioactive waste shall be managed in such a way that will not impose undue burdens on future generations.” This discussion reveals a link between concept of retrievability and the question whether future generations will be ‘smarter’ than the present one in relation to the question what constitutes an ‘undue’ burden in this context. Some interviewees state that there is basically a choice between two evils. On the one hand, assuming that knowledge about RWM is likely to decrease over time, it is better to put the waste deep underground (and never touch it again). This is fair to future generations if we assume they will be less knowledgeable and cannot bear the burden of taking care of the waste. On the other hand, assuming that nuclear knowledge can be preserved and transferred to future generations, people may get smarter and find better solutions for the waste. In that case, it is fair to future generations to keep this waste accessible for as long as possible. In that situation, inaccessible waste could be seen as a burden.

One interviewee states that our inability to communicate to generations in the far future may well be the greatest obstacle to geological disposal. If knowledge can be transferred successfully, which most interviewees tend to assume, this is an argument in favour of either prolonged surface storage or deep geological disposal with retrievability. Both

options have disadvantages, it was mentioned. In case of geological disposal, keeping a mine open is expensive and cannot last forever. In case of surface storage, it will be easier to use the waste for terrorist or war purposes.

Interviewees have different ideas about how to foster acceptability of both the process (how) and the contents (what) of geological disposal. Several interviewees tie acceptability to the ability of decision makers and experts to demonstrate safety and liability to stakeholders. Two other interviewees relate degree of acceptability to the extent emotions are being allowed in a public debate. While usually either put aside as 'NIMBY-ism' or answered with proposals for monetary compensation, emotions can reveal relevant societal and ethical information that should be incorporated in the debate, because attempts to ignore them would be counterproductive to acceptability. Interviewees arguing for allowing emotions in the debate at the same time argue that stakeholders should have the opportunity to enter a debate well-informed. In other words, they do not state that information is unimportant but that information is not everything.

Regarding collective responsibility, the notion of 'no free lunch' was mentioned. In order to establish effective public participation, everyone should realize that radioactive waste is something for which all members of the present generation share responsibility. Related to this point, some interviewees plea for more attention to comparative risks of alternative sources of energy production and use. They argue that more attention should be given to comparing and weighing both local and societal risks of different solutions to continue energy production. Several interviewees also argue that the problem of chemical waste is downplayed compared to the problem of radioactive waste, amongst others because chemical waste remains equally dangerous through time. Linking RWM directly with the general discussion about energy provision might also foster public involvement. Linking the complex long-term issue of geological disposal to the present-day issue of energy provision can make it easier for people to understand that every choice or non-choice, at personal as well as societal level, has implications.

#### 7.3.6. How to organize decision-making and participation?

Eight aspects relevant for decision-making and participation were brought up in the interviews: Responsibility was brought up in all interviews, and the need for dialogue and openness in almost all of them. The need for (consensus on) a knowledge base, awareness of the interdependence of issues, and the need for a no-regret policy were brought up in about half of the interviews. The reliability of senders of messages about RWM and "taking sufficient time for the process" were both mentioned in some of the interviews. Each of these aspects is discussed below.

##### **Responsibility**

There are roughly two views on how the decision-making should be organized. Some interviewees argue that the government should be in the lead, through the democratic process as we know it, informed by experts. Other interviewees believe that no existing institution is sufficiently trusted to take decisions about RWM, due to the long-term implications of such decisions. They recommend that a new type of decision-making institution should be developed, representing a wide range of stakeholder interests, that would be trusted and legitimized to act on their behalf. It was difficult for them to envision such an institution, though the Dutch Social and Economic Council's (SER) energy agreement was mentioned as an example. One interviewee argued that such a decision-making institution - specifying its task as the 'memory' and 'consciousness' of the RWM issue - would have to be installed on European level, given the likelihood and logic of international cooperation. Other interviewees also envisioned interconnected institutional platforms on different levels: EU level, national level, local level, each with its own

dynamics and central questions. One interviewee compared the process to the implementation of the euro as agreed currency.

### **Dialogue**

Most interviewees agree that ‘all great changes begin at the dinner table’: taking time, listening, and talking about the process rather than about solutions are vital to a satisfying outcome. Dialogue and process should have central and continuous attention, also financially - it takes time, expertise, and thus money to facilitate enduring stakeholder involvement. However, there is a subtle difference between interviewees who regard these elements as necessities to gain acceptance and interviewees who regard these elements as part of a proper democratic process. The latter argue that it is vital that the magnitude of the problem is recognized and acknowledged at the start of the process before attempting to agree on ‘the’ solution. Furthermore, given the high uncertainty about what constitutes the best solution to RWM and geological disposal, particularly in the long run, one must purposely and continuously invite critical views to the process. The government should coordinate and ensure - for instance by delegation to an independent and trusted party - equally strong and serious facilitation of participation in the decision-making process for anyone who feels involvement with the issue. Giving citizens a “right to veto” is suggested by two interviewees, as the example of RWM in Sweden as well as research on public participation shows that for many people, having the opportunity to change a situation (for example, switch nearby wind turbines off with one phone call when they cause disturbance) fosters the acceptability of that situation (in practice the phone line to shut down turbines was only called once or twice).

### **Openness**

Openness in this context refers to the willingness to discuss scientific uncertainties. One interviewee refers to a quote in the Finnish documentary ‘Into Eternity’: ‘the reality of the thing is: nobody knows anything at all’. To the best of our present knowledge, geological disposal is the safest option. But nobody can and should claim that this option will provide absolute safety. This is what the Dutch government should communicate<sup>26</sup>. There is no reason to make RWM look prettier than it actually is, and doing so may well backfire in public opinion.

### **Knowledge base**

If public participation is taken seriously, it requires that participants share a basic understanding of key concepts as well as agreement on the definitions of these concepts. For example, which types of radioactive waste can we discern? Which quantities? What are the sources of this waste? For how long will it remain so dangerous that it has to be put away? Interviewees agree that the availability of undisputed knowledge, tailored to different levels of comprehension and interest, is a prerequisite. Government and RWM experts must be willing to take the time to show what they are doing.

### **Interdependence**

Some interviewees mentioned the importance of relating the matter of radioactive waste to other issues, but they differ as to which other issues are important and why. Some state that the discussion should be linked to other types of waste, particularly chemical waste. Others state that the RWM discussion should be linked to (nuclear) energy production. Still others state that this would be impractical since each of these matters is dealt with by different groups of decision makers and stakeholders. The point of interdependence relates to the knowledge base: participation requires agreement on which issues are and

<sup>26</sup> note that this agrees with the current view in RWM, see e.g. wording chosen by IAEA in Section 2.1, p.8



which are not parts of the discussion. One interviewee also brought up the complexity of calculating, comparing and weighing risks from several options.

### **No-regret policy**

Most interviewees stated that decision-making should be reversible to avoid a lock-in situation. Apart from The Netherlands not yet being able to afford geological disposal, the present policy of 100 year interim storage provides the opportunity to learn from other countries. Some interviewees regard a no-regret policy as a necessity to obtain acceptance while others view it more normatively as the proper way of conducting the process of decision-making.

### **Reliability**

Reliability refers to the sender of messages about RWM. At present, these are mainly the government and the (state-owned) implementing organisation. Some interviewees state that reliability can be improved if messages would come from the aforementioned independent decision-making body.

### **It takes time**

Several interviewees consider taking time as a crucial step towards acceptance. Taking time, for example to learn from experiences abroad is a good thing. Unnecessary postponement of the implementation of a solution should be avoided, as the generation who has caused the problem has to provide a solution too.

## *7.4. Conclusions*

The primary objective of the in-depth interviews was (a) to identify key uncertainties related to RWM in general and uncertainties specific for the Dutch RWM policy (retrievability requirement, long-term interim storage, multinational cooperation as option) and (b) to elaborate main considerations regarding both the short-term and the long-term decision-making process. Conclusions on each key uncertainty are presented in Section 7.4.1 and conclusions related to the short-term decision-making process are summarized in Section 7.4.2. Section 7.4.3 provides conclusions specifically on the role of reversibility, retrievability, and staged closure. In Section 7.4.4 we provide some conclusions concerning the specific challenges within the national context in The Netherlands.

### **7.4.1. Managing key uncertainties related to RWM**

The most frequently discussed uncertainties are related to societal aspects: gaining acceptance, trust in technology, organisation of the process, and long-term societal dynamics. For gaining acceptance, we conclude - in agreement with international guidelines - that public engagement should meet two equally important requirements:

- Before entering discussion, inform participants on key elements of geological final disposal in a way understandable to a lay public. Nobody can be expected to contribute constructively to a complex discussion unprepared<sup>27</sup>.
- Establish a dialogue in which there is room for the public to bring forward valuable knowledge about, for example, (local) historical, social, institutional, cultural, or ethical aspects that can be of relevance to the demonstration or implementation of technical solutions.

As discussed in Chapter 5, there is a broad agreement in RWM that access to information and active dialogue with stakeholders is a key factor for a successful implementation. The

<sup>27</sup>see also [39]



necessity to present the safety case in an understandable manner to a broad group of lay-stakeholders is clearly recognized and reflected in the general structure and many elements of the safety case methodology (e.g. by defining a set of safety functions, by defining indicators of safety and performance, or by providing a set of safety statements as central outcome [34, 36, 36, 101, 102, 103, 104]). In spite of these efforts, the communication of safety case outcome to a broad public is still acknowledged as point of concern [105], also reflected in the ongoing OPERA programme [3, 39]. Based on previous research on public engagement on the topic of Carbon Captures & Storage (CCS) [106, 107] it can be noted that providing knowledge is a necessary but not sufficient ingredient to influencing public opinion. This aspect of communication is further elaborated in the OPERA project CIP [39].

Though levels of trust in technology vary among stakeholders, particularly trust in the ability to predict risks over a long period of time, most interviewees agree that insights about the best solution today may be subject to change in years to come. There is consensus among the interviewees on the importance of continued investments in (independent) research. Given that the desire for independent research is a binding factor for stakeholders, it is recommended by some interviewees to further discuss how to embed scientific research in such a way that findings can be trusted by all stakeholders. See [108] for a discussion on the role of science in complex societal issues such as CCS.

In organisation of the process (towards siting), two phases should be discerned: The phase before location selection and the phase after location selection. Both phases are challenging in very different ways. This observation in the interviews is in line with the general view in RWM (Section 5.1). The specific challenges related to the involvement of local stakeholder are extensively discussed in literature (e.g. [49, 51, 52, 59, 70, 75, 87])<sup>28</sup>. In the phase before location selection the main challenge is how to organize a continuous dialogue between relevant stakeholders on RWM towards geological disposal as a solution to be implemented sometime, somewhere. It is recommended at this stage to take care that also stakeholders who oppose nuclear technology are involved in the discussion, even if they prefer not to be part of the “process”.

Long-term societal changes are so unpredictable that any decision on RWM may best be based on societal values that tend to be relatively stable over time, an approach that is taken over in the set-up of the stakeholder workshop (Chapter 8). Two main values in the RWM debate are intergenerational equity and collective responsibility. Appeal to these values in discussions on RWM may help decision-making moving forward<sup>29</sup>: appeals to collective responsibility can motivate present generations to do their share in solving the problem, while appeals to intergenerational equity can motivate present generations to ensure that generations directly following theirs (children, grandchildren) are equipped to take the next step. One important task for current generations will be to pass on the feeling of importance of RWM as a societal issue that should never fail to receive priority. Like one respondent remarked, somehow the ‘memory’ and ‘consciousness’ of the RWM issue should be kept vivid.

#### 7.4.2. Considerations regarding short-term and long-term involvement

Above all, on the short term, clarity is needed on which parties bear what responsibilities and whose view they represent. Though roles of the government, COVRA and other stakeholders may in great lines formally be clear (see Section 2.1), it is unclear which

<sup>28</sup>although in this report limited attention is given to the topic, due to the long timescale before such a decision is foreseen (in 2115, see **Figure 3-2**)

<sup>29</sup>see also Section 2.3 and Chapter 5 in the CIP report [39]

party will take which role in the development and roll-out of stakeholder engagement strategies in the next decade. However, as discussed in Section 5.2, transparency of the process and of roles and responsibilities is acknowledged as important aspect of a successful implementation of the RWM programme (see also Table 5-3). It is therefore recommended to clarify roles and responsibilities to the stakeholders.

Though interviewees had no problem accepting the view on geological disposal as the best solution known to date, findings from the interviews recommend that for constructive stakeholder discussions some points are important to bear in mind. Firstly, stakeholders are highly sensitive towards the complexity of the matter. Anyone making strong claims about knowing the best and safest solution is likely to meet distrust. Secondly, and related, some stakeholders will mention there are other possible solutions for RWM that may return to the table at some point. This should be acknowledged. Thirdly, many stakeholders feel that the basic notion should be to reduce the amount of high-level waste to a minimum with all technological solutions available. This should be discussed. Finally, and related to the former point, for some stakeholders it will be difficult if not impossible to involve themselves in formal discussions about geological disposal as long as the amount of waste continues to increase through the production of nuclear energy. A way should be found for these stakeholders to participate in discussions on RWM with acknowledgement of this viewpoint.

Long-term recommendations are rather abstract but universal to proper decision-making regardless place and time. Interviewees stressed the importance of dialogue, openness and trust, in line with the common view in RWM (Chapter 5). What this would mean in a decision-making process is best illustrated by an example of a case where these elements were absent, such as the case of CCS in Barendrecht [109]. Generally, arguments against CCS show resemblance to arguments against geological disposal: CO<sub>2</sub> should not be emitted in the first place, there are other solutions than CCS, the CO<sub>2</sub> will never remain underground long enough, what if we find useful applications for CO<sub>2</sub> in the future, an underground repository is likely to leak at some point and do harm to the environment, and the government cannot be trusted to take care of the monitoring for the required period of time after closure. In Barendrecht, one of the most well-known examples of a CO<sub>2</sub> demonstration project that failed due to local resistance, parties who raised such arguments did not feel listened to by proponents of the project. The immediate result was cancellation of the project; the final result was removal of CCS as a climate mitigation strategy from the Dutch policy agenda. Findings from research into the case indicated that it would have been wise to organize a wide societal discussion on the role of CCS as a strategic part of energy transition. Studies on public acceptability of CCS in Scotland and Poland confirmed that acceptability of CCS is related to other measures to combat climate change [110]. In The Netherlands, such a discussion never took place. Should CCS ever return on the Dutch policy agenda it is expected that it will instantly meet local resistance, as does the issue of geological disposal at present among the same stakeholders who were active in the discussion in the 80s. In this situation, trust will have to be built first. Societal processes take time, and the implementation process for a geological repository is therefore best started while ample time is still available.

#### 7.4.3. The role of reversibility, retrievability, and staged closure in the implementation of a geological disposal for radioactive waste.

At present, retrievability as an issue is not top of mind for the interviewees. Issues related to the questions when and where to start constructing a disposal were much more salient. The advantages and disadvantages of retrievability were briefly discussed, but knowledge levels among the interviewees did not allow for discussion about either the specification of the Dutch requirement for retrievability or an interpretation of the stepwise decision about final disposal in the light of retrievability. The reasons mentioned in favour of

retrievability - necessary to enable the correction of ‘mistakes’ and to enable future generations to find other solutions - do underline the importance of enabling and facilitating application of new and improved knowledge in each step taken in the implementation and operation of a disposal facility - and the possibility to reconsider steps when needed. For an in-depth stakeholder discussion on how to shape such a process in terms of stakeholder participation it is recommended to develop a ‘narrative’ on reversibility, retrievability and staged closure (see chapter 9) that can serve as backbone to an informed discussion. Present knowledge levels among stakeholders are simply too low<sup>30</sup>.

#### 7.4.4. Conclusions with respect to the specific context of The Netherlands

The interviews comprise a broad spectrum of topics and a variety of discourses. As pointed out in the previous sections, many of the themes addressed by the interviewees are in line with common views on RWM as summarized in Chapter 2 to 5, or they cover common concerns addressed by the safety case methodology (Section 2.3.2). As these points are expected to be sufficiently addressed by the OPERA Safety Case, this section focuses on aspects in which the national context or findings deviate from other countries.

##### **Acceptance of geological disposal as an endpoint**

From the interviews it is evident that geological disposal, as a widely accepted endpoint of (at least) long-living radioactive waste, is still a point of discussion in The Netherlands. Thus, ‘openness’ concerning the RWM solution is recommended by some interviewees (Section 7.4.2). Arguments for more openness range from stressing the relevance of reuse or reduction of waste, over the notion that as long as waste is produced (i.e. by nuclear power plants), disposal is not a ‘solution’, to optimism that eventually techniques may evolve that allow better solutions than geological disposal. However, to prevent loss of focus in the decision-making process always a clear, concrete goal of the process should be in place. The need for openness in the process can then be achieved by periodic evaluation of that goal, which may lead to adaptation or replacement by another one. The shared belief of the RWM community is that geological disposal is the only safe endpoint on the long term (e.g. [111]), and while it is expected that there will always be stakeholders that will not be convinced of the safety of that solution. Therefore, a broad-based agreement on geological disposal as endpoint between stakeholders is judged as beneficial and should be part of a shared understanding of the problem (see Section 5.4).

Although waste reuse and reduction are already important part of the national policy on RWM (e.g. [18]), some interviewees were apparently not aware of this. It is important for RWM to pursue a common understanding that whatever progress will be made in the reuse of waste or in reduction of the waste generation, a safe long-term disposal solution will always be required.

The link between waste disposal and nuclear energy production (or the use of other nuclear technologies) must be considered as a valid argument of stakeholders who are not convinced of the safety of a geological disposal design. Involving these stakeholders in the planning and decision-making process is challenging. Similar to the diverging opinions expressed in the interviews, different approaches can be seen in literature. In [112; p.9], it was recommended that it should be clarified if these stakeholder have any objections against the rules of participation, and if they do not wish to participate for other reasons, this should be made transparent.

<sup>30</sup>To address this more adequately, an additional public report on this topic has been prepared [62].

The ‘hope’ that someday better solutions may emerge (note the resemblance with discussion in CCS, Section 7.4.1) is an irrefutable argument that should be addressed by any policy on RWM (see also [62]). While other countries - for instance Sweden and France - may have some practical logistic arguments at hand, the Dutch policy of long-term interim storage could lead to the situation that a wide range of future RWM scenarios remain open for consideration. The acknowledgement on related uncertainties should be part of the RWM programme, but currently the national policy does not explicitly address the way this issue is handled. Following the guidance given in Chapter 5, a broad stakeholder dialogue about the general approach towards this long-term uncertainty is needed. As such a discussion is primarily not based on deep insight into scientific-technical details of radioactive waste disposal, but rather on the general topic of how to handle uncertainties, such a dialogue could be initiated in the near future.

### **The long timescale of implementation**

Specific challenges related to the Dutch policy on long-term interim storage are discussed throughout this report. A general need for more transparency was noted in the interviews (see also next paragraph), and accompanying uncertainties were widely discussed. However, no explicit statements were captured on what needs to be done or achieved in near future, and for which aspects it is possibly wiser to follow a reasoned ‘wait and see’. The aspect of *burdens to future generation or intergenerational equity* was discussed, but mainly focused on the topics *uncertainty*, *knowledge transfer* and *keeping management options open for future generations*. This raises the question: what should be the purpose and scope of a more detailed and transparent elaboration of the RWM policy and the role of different actors - as recommended by some interviewees and the common literature cited in Chapter 5 - regarding the long-term interim storage policy of The Netherlands, where the first relevant decision is foreseen not before 2080? This topic will be revisited in Chapter 10.

### **Needed information on RWM policy, roles and responsibilities**

Transparency of the process and of roles and responsibilities was acknowledged in Section 5.3 as an important aspect of a successful implementation in RWM. This was also brought into discussion by several interviewees. The perceived lack of transparency may be partially due to the current, early stage of RWM in The Netherlands, and partially linked to the long-term interim storage. Since many recommendations of the interviewees point towards an early involvement of stakeholders (see Section 5.4), this should be considered as an opportunity rather than interpreted as a shortcoming of the Dutch RWM.

### **Retrievability as requirement**

Although the topic of retrievability is under discussion in other countries as well, The Netherlands have a long historical commitment to it: retrievability is described as a requirement of the national RWM policy since two decades. However, the interviews showed that this topic is not the most salient in the current stage - partly because other topics are judged to be more relevant and partly because the issue of retrievability is considered to be too complex to discuss in exploratory in-depth interviews.

A shared understanding of the role of retrievability could form the basis of a broad-based agreement between stakeholders on the overall disposal process as well. However, as pointed out in the previous paragraph, transparency on the overall process, roles and responsibilities might be higher on the agenda. For a more detailed analysis, conclusions and recommendations on the overall topic it is referred to the RESTAC topic report on retrievability, staged closure and monitoring [62].

## 8. Workshops

Two workshops have been organized within the framework of the ENGAGED and RESTAC projects: an expert workshop and a stakeholder workshop. Goal of the expert workshop was to receive advice from the experts on the methodology to develop scenarios and the building blocks for the scenarios. The objective of the stakeholder workshop was to discuss the decision-making trajectory about a deep geological radioactive waste disposal, the conditions for that trajectory, and the preferred involvement from the perspectives of different stakeholders.

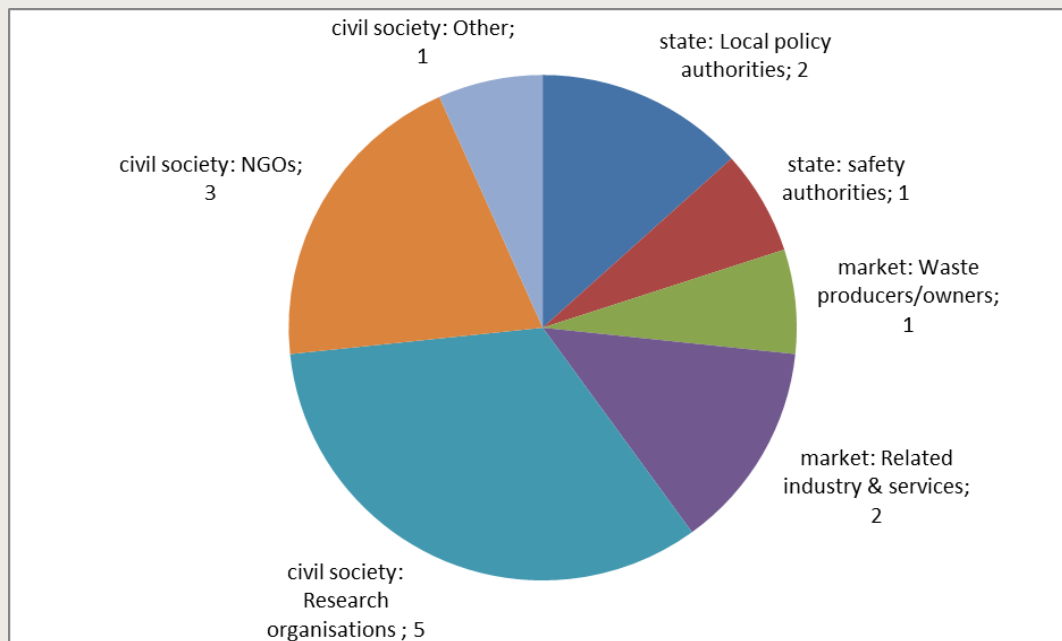
### *8.1. Selection of participants*

The participants of the ENGAGED/RESTAC workshops have been carefully selected in such a manner that persons from different backgrounds were represented at the workshop. Two workshops were organized: an expert (scenario) workshop and a stakeholder workshop.

Experts from different fields of expertise (scenario development, radioactive waste, societal trends, safety and risk) from universities, research organisations, advisory bodies, the market and a civic organisation were invited to participate in the first workshop. These experts were asked to discuss the methodology to develop the long-term scenarios for the decision-making process about nuclear waste disposal including uncertainties influencing decision-making. Ten experts were invited to the workshop and nine participated in the workshop.

Stakeholders of national authorities, local policy authorities, safety authorities, the market (waste generators/users and services), research organisations, NGOs and other civic organisations like churches, tourist and cultural organisations (see Section 6.1) were invited for the stakeholder workshop. That workshop was planned for June 2014 and in total 30 stakeholders were invited. Due to a too limited number of positive responses (7), that workshop had to be cancelled. There was a lack of representation of NGOs, scientific experts and other organisations (churches, tourist and cultural organisations). Therefore it was decided to postpone the workshop until September 2014. In the period between June and September in total 45 stakeholders were approached and invited to the workshop. Eventually 15 stakeholders from different backgrounds participated in the stakeholder workshop (see **Figure 8-1**). Particularly representatives from local policy authorities, NGOs and other organisations were difficult to engage. Expressed reasons for organisations for refusing participation in the workshop were lack of budget and time constraints, which are both related to the fact that radioactive waste disposal is currently low on the political agenda in The Netherlands. The stakeholders who did participate in the workshop were mainly persons that were already involved in the radioactive waste disposal discussion.





**Figure 8-1: Background of stakeholders that participated in the stakeholder workshop.**

### *8.2. Expert workshop*

According to the ENGAGED project plan the scenarios and building blocks for scenarios were discussed in the expert workshop, in order to receive advice from the experts on the methodology to develop the scenarios and the building blocks for the scenarios. An explorative scenario methodology was proposed that is appropriate for dealing with long term uncertainties and delivers answers and robust responses to strategic questions or issues. The scenario stories should be coherent, lively and imaginable stories about the future, and should be developed in a participatory approach. Based on the main uncertainties identified (see section 7.3), several draft scenarios were constructed for the year 2130.

The main questions that were posed to the experts were:

- Regarding the key question to be answered with the scenarios: “How should the long-term decision-making trajectory about the long-term radioactive waste disposal be arranged and what requirements and conditions should be fulfilled as to lead to societal acceptable decisions?
- About the methodology to develop the scenarios;
- The time frame of the scenarios: long term (2130) or shorter term (2040/50)?

The expert workshop was organized on 15 January 2014. The complete report of the workshop (in Dutch) can be found in appendix 5.

One of the problems the research team met was that it is hard to develop scenarios for the very long term (2130) that are meaningful for the decision-making trajectory about the implementation of a radioactive waste disposal. As there are many uncertainties about the societal conditions and how decisions will be made in 2130, it is hard to find the main uncertainties on which the scenarios will be based.

The experts reflected on this problem and advised to develop scenarios that are more imaginable and capture a time horizon of about 20 years. Furthermore they advised to work with imaginable events and incidents that could happen during the chosen time



frame and that could influence the decision-making trajectory significantly. One could think of events like a sudden shift in politics towards a centralistic hierarchic government because of a shift in voters' preferences. Another example is the impact on societal aspects from an event like a disaster with nuclear waste transport. These type of events could both slow down or speed up the decision-making process, influence the way the decisions will be taken, and also the way stakeholders should be involved or not in the decision-making.

Based on this advice, the research team decided to follow a practical approach that facilitates a discussion with stakeholders about the important conditions and factors influencing the decision-making process. The scenario story is then to assume that certain events in 2015 lead to the situation that the decision should be taken earlier and consequently the disposal facility should be realized earlier. This discussion will then be much more realistic, as the present generation should take the decision. It is an exercise that is needed to surface arguments and considerations of the stakeholders about their involvement in a decision-making trajectory about long term radioactive waste disposal, that otherwise probably would have stayed very abstract.

### *8.3. Stakeholder workshop*

To discuss the decision-making trajectory about a geological radioactive waste disposal, the conditions for this trajectory, and the preferred involvement from the perspectives of different stakeholders, a workshop with stakeholders from different backgrounds was organized on 10 September 2014. As was discussed in the previous section stakeholders were asked to imagine the decision-making process should start very soon as to make a decision in 2030/2035. This would mean that this generation should take the decision. Topics relevant for the decision-making and related to participation were discussed (in the frame of ENGAGED), and a separate discussion was organized on reversibility and retrievability (in the frame of RESTAC). In the following sections the results of the discussions are summarized. The complete report of the workshop (in Dutch) can be found in Appendix 6.

#### **8.3.1. The decision-making process and stakeholder participation**

The topics discussed in the workshop are presented below.

##### **The long term character of the decision**

Although the participants in the workshop were asked to act as if the decision about the deep geological radioactive waste disposal should be made earlier, they were of course aware of the fact that in reality this decision will be made much later (around 2100/2130), and there is currently a lack of political urgency on this topic. How to get people involved then, if it is not an issue now? This absence of urgency was even reflected in the participation in the workshop: it was quite hard to get a good representation of stakeholders. For some of the stakeholders this absence of urgency is not a big issue: "we can wait". Others point at the responsibility that we have now for the disposal of the radioactive waste that is already present. Ways to get the issue higher on the public agenda were explored in the workshop. Firstly, through widening the scope of the discussion: discuss not only the disposal of radioactive waste, but discuss it in a broader frame, like the future of The Netherlands, or the future of The Netherlands' energy supply. In that frame the future of nuclear energy should also be discussed. Secondly, through starting the discussion about a geological radioactive waste repository now, in order to prepare for the decision-making. At this moment there is already radioactive waste, and therefore, we should take the decision about radioactive waste disposal in this generation. Some of the participants were prepared to invest time in this. One of the NGO's wants to organize the discussion about this with other parties involved. In the workshop it was discussed that for a fruitful discussion, the coordination with other involved parties is

essential: it should be a joint effort. The long term character of the decision trajectory about the geological disposal of radioactive waste hampers the discussion now.

### **The decision-making process**

During the workshop, steps in the decision-making trajectory were discussed that refer to the steps in Chapter 3, but were simplified as to make them fit for a discussion with stakeholders. The steps were:

- Selection of the fractions of radioactive waste that should be disposed;
- Selection of host rock and disposal concept;
- Choice between a national or multinational disposal facility;
- Specification of the role of retrievability in the decision-making process;
- Specification of the role of participation in the decision-making process;
- Specification of safety requirements and procedure to demonstrate the safety of the facility;
- Site selection.

The selection of fractions of radioactive waste for disposal should be based on a transparent technical analysis and is found important as it influences the disposal specifications (type and dimensions of the disposal).

The selection of host rock and disposal concept is closely related to the site selection as the occurrence of host rock (and depth of it) will confine the possible locations. Some stakeholders stressed that an integrated assessment of the feasibility of the underground (in relation to other uses) is needed.

The choice for a national or multinational disposal facility widens the site selection to the more suited locations in an international perspective. The Netherlands doesn't generate much radioactive waste, and according to some of the participants in the workshop, a more cost-effective solution could be reached if a waste facility could be shared with other countries. On the other side it was stressed that The Netherlands then also should receive radioactive waste from other countries if the better suitable disposal site happened to be located in The Netherlands.

Retrievability of the radioactive waste was discussed more in depth in a separate part of the programme.

The role of participation was found an important aspect of the decision-making process as it creates social support for the decision-making process and gains acceptance for decisions (see next section).

Specification of safety requirements and the procedure to demonstrate the safety of the facility involves explicitly risk and safety aspects of the disposal facility. Participants find the risk and safety assessment an important aspect of the decision-making process which requires a solid scientific and technical basis, and should be done in dialogue with local communities. The risk concept itself should also be discussed. The drinking water sector indicates it doesn't want to accept any risk for ground water.

For the site selection the participants indicate that a 'bottom-up' approach should be followed instead of a 'top-down' approach (a compulsory designation of a site). A process is needed in which several sites can be discussed and local communities are involved for the final site selection.

According to the participants, the following decisions were missing:

- For some of the NGOs phase out of nuclear energy is a precondition to participate in the (discussion on) decision-making process;
- The integrated approach of the use of the underground is missing (the aforementioned integrated assessment of the feasibility of the underground in relation to other uses). The Dutch Government works on a “vision on the use of the underground” which should be included in the decision-making process;
- A discussion about the norms and values of present and future generations that are touched upon in the decision-making process should be organized;
- Preceding the actual decision-making process, a decision should be made about the decision-making process (see next section).

### Stakeholder involvement

The ladder of participation has been introduced by Arnstein [113] and was adapted by Gerrits and Edelenbos [114] for soil and water related issues. The different degrees of participation that were presented in the workshop are:

- Information: providing information to stakeholders;
- Consultation: consult stakeholders to hear what they think that must be done;
- Advising: stakeholders give advice about the policy or measures that should be taken. Their recommendations should be taken into account by the policy organisation;
- Co-producing: stakeholders are regarded as equal policy makers but decision-making remains in the political domain;
- Co-deciding: decisions are made together and stakeholders have decision-making power.

The participants could indicate for each decision in the decision-making process at what degree of participation they want to be involved. The results of that exercise are given in **Table 8-1**. From the table it can be seen that there is a preference towards “advising”, as this category is mentioned 33 times, while the other categories have a more or less equal preference from stakeholders (ranging from 11-18 times). Stakeholders want to be involved at a higher degree when it comes to the decision about the role of participation. For that decision the category “information” is absent and it seems that they want to be more closely involved in that decision. This became clearer from the discussion in the workshop on this topic: some of the stakeholders advocate a decision about the decision-making process. That step precedes the actual decision-making process and all aspects of and conditions for the decision-making process (what are the decisions that will be made?, who makes the decisions?, who should be involved?, when?, at what degree?, etc.) can be discussed and arranged in that step. Some of the participants find that a decision on nuclear energy in The Netherlands should be part of these pre-arrangements for the decision-making process.

**Table 8-1: The preferences of the stakeholders**

Decision steps	Information	Consultation	Advising	Co-producing	Co-deciding
Disposed fraction	6	1	4	1	1
Host rock and disposal concept	2	3	5	1	2
National or multinational disposal	1	4	5	1	2
Retrievability	3	2	3	3	2
Participation	-	4	4	2	3
Safety requirements	1	2	7	2	1
Site selection	2	2	5	1	2
Total:	15	18	33	11	13

The role of citizens and local communities was also discussed in the workshop. On the one hand the lack of knowledge of citizens about radioactive waste was stressed - which could hamper their involvement in the decision-making process - while on the other hand the unique kind of knowledge of citizens (local knowledge on culture, history etc.) was also mentioned which should be used in the decision-making. A role of citizens in the decision-making process as a kind of “watchdog” of the process, asking for attention when some aspects get too much or too low emphasis in the process, was also discussed.

### **Safety, risk and uncertainty**

There was a high consensus among the participants of the workshop that safety and risk play a major role in the decision-making process for a radioactive waste disposal facility. These issues require a solid scientific and technical basis. The scientific basis should not only contain the natural science aspects, but also social science aspects, like exploration of norms and values that are addressed, risk perception issues, and ethical issues, for instance on how to deal with future generations in the decision-making. The scientific basis should be shared with relevant stakeholders and local communities (see section on “the knowledge base”).

Uncertainty is another aspect that plays a major role in the decision-making about a radioactive waste disposal facility, as this requires an extreme long time horizon and long term planning. Uncertainties that were mentioned in the workshop are related to the calculations with respect to risk and safety and technical feasibility of the disposal facility and are also related to the long term behaviour of the underground (groundwater, earthquakes), climate change and its impacts like sea-level rise, flood risk and temperature rise. There was a consensus among the participants in the workshop that the decision-making should explicitly deal with uncertainty (and the mentioned uncertainties). The way how this should be done was not discussed, but it addresses a challenge for politics and decision-making, as a method to adequately and explicitly address uncertainties on this topic is still lacking and should be developed.

### **Transparency, openness and trust**

Transparency and openness of the decision-making process were discussed in the workshop as important factors to gain trust, as trust is an important carrier for the decision-making process. Transparency would mean that it is made clear from the beginning how and when decisions are being made, who takes the decisions, based on what, etc., sort of “rules of the game” for the decision-making. This is also related to the proposal to take a decision about the decision-making process (see under stakeholder involvement).

Openness means that decision makers are open to signals from society, stakeholders and communities. These signals should be taken serious in the decision-making. It also means that certain stakeholders or communities that want to take part in the decision-making in a later stage, can do so. Another variant of this was also discussed. As the decisions makers form a relatively small group, the risk of “group think” [115] is present. To prevent this it was suggested to involve parties in the process that are not closely related to the issue. The proposal to involve citizens as a “watchdog” in the decision-making is also related to this.

Trust is vital for the decision-making, especially for such a complex and long term issue as the realisation of a radioactive waste disposal facility. Participation (and admission to all information), is besides transparency and openness another important factor to gain trust. It was discussed that trust can also be generated by parties that are not related to the issue and are trusted by the public (for instance drinking water companies).

### **Interplay between authorities**

The interplay between authorities involved on different levels of decision-making (national government, provinces, and municipalities) was discussed in the workshop. The participants in the workshop regarded a mere “top down” process equally unrealistic as a mere “bottom up” process, therefore a productive mix of the two should be found to take joint decisions. This starts with a good interplay between the involved decision makers at different levels. The division of roles, the explicit separation of roles, and the division of power and responsibilities over the decision makers were mentioned as important factors for such interplay. These could be taken up in the “decision about the decision-making process”.

### **The knowledge base**

Several times in the workshop the role of (scientific) information and knowledge was mentioned as an important factor that should receive explicitly attention in the decision-making. According to the participants, a ‘knowledge base’ should therefore be created and maintained, also to ensure that knowledge and lessons learned are retained. The knowledge base should be shared among scientists, decision makers, stakeholders and citizens, and should allow for discussions on the relevant information and how to develop this further: on what information is there consensus and on which information not? What to do with information on which there is no consensus: do further research? The knowledge base is not only a “library”, but also an instrument to discuss scientific information and articulate new questions for research together with all involved in the decision-making process.

#### **8.3.2. Reversibility and retrievability**

In the workshop several topics with respect to reversibility and retrievability were discussed. To open the discussion on retrievability the following question was discussed:

*What is the period that the radioactive waste should be retrievable?*

The participants could choose from five categories of answers:

- a) Retrievability is not necessary;
- b) Only without extra risks and costs;
- c) Until the facility is being closed;
- d) Retrievable after closure of the facility;
- e) In principle always retrievable.

The discussion addressed firstly the concept of “retrievability” and the technical feasibility of it. In principle the radioactive waste is technically retrievable as long as you can dig a hole to it and can reach it, according to some participants. So, this would mean that radioactive waste is technically always retrievable and it reduces the question then to: “at what cost”? From the possible costs for retrievability the discussion went to the safety issues: how can we be sure that we cover all relevant safety issues as it concerns such a long term? As the participants didn’t like to discuss the question about the period that radioactive waste should be retrievable (too concrete), the discussion went over to the next question:

**For what reasons should radioactive waste be retrievable? What societal or technical objective would be served with this?**

The arguments exchanged in the discussion on these questions were quite broad and stakeholders’ positions appeared to be not very firm as they could easily change their position and mention arguments from several perspectives. Stakeholders’ arguments and considerations for retrievability are future technical solutions for long lived or high active



radioactive waste, and ethical issues as future generations still can reach the radioactive waste and can implement new solutions. Opposite also disadvantages of retrievability were mentioned: higher costs and safety issues, like human intrusion (for instance people who want to use the waste for terroristic actions). As one of the options for maximum retrievability an above ground waste facility was also mentioned (so continuing the present situation in The Netherlands for a longer period). On the other hand, arguments and considerations for irretrievability are human intrusion and lower maintenance costs. Opposite were mentioned: 'the idea of irretrievability is a fiction as the waste is always technically retrievable' and ethical issues like 'hiding the waste deep underground'. The discussion touched also upon the uncertainty about the costs of retrievability: is it possible to assess these costs as there are so many uncertainties involved and the period is so long?

Then the last question was discussed:

#### **What are the risks of reversibility of decisions and stepwise closure of the disposal facility?**

According to the participants reversibility of decisions sounds initially nice, but the downside of it is that coming back to earlier decisions leads to vague decision-making (even "no decisions") which in turn can lead to diminishing trust in decision makers. Reversible decisions will also lead to higher financial risks, and related higher uncertainty. Stepwise closure requires a responsible institution or organisation that exists during all the steps. The continuity of the organisation is therefore a crucial aspect: how long is the period of stepwise closure?; is it possible to guarantee the existence of the organisation during this period?

Summarizing the discussion, the issues reversibility and retrievability are apparently very complex and it is questionable whether this can be discussed without a deeper investigation of these topics. The discussion reflects this as it generated no answers, but rather more questions relevant to the topic. Topics that were mentioned are safety issues, costs, and ethical aspects especially related to future generations. Dealing with uncertainty is very relevant for retrievability and reversibility.

### **8.4. Conclusions**

#### **8.4.1. General expectations on the decision-making process**

The conditions, requirements, and considerations for the decision-making process for a geological disposal as expressed by stakeholders and experts in the interviews and the stakeholder workshop are generally in line with international literature as presented in this report. These include responsibility for future generations, safety as a primary concern, dealing with uncertainties in the long term decision-making process, reversibility of decisions, the role of participation, the importance of a fair and trustful decision-making process and the roles and responsibilities of the institution(s) that will take the decisions.

Ethical issues of the decision-making process were mentioned many times and are one of the main concerns of stakeholders and experts. How to generate intergenerational fairness and how to deal with the norms and values of future generations in the decision-making process as these will change over time? Some stakeholders want to deal with these aspects by reversibility of decisions or maximum retrievability of the waste. Others fear indecisiveness or are more concerned about risk related to retrievability and want to design a geological disposal in a way that makes access for future generations as difficult as possible. Indecisiveness as a result of all potential caveats to intergenerational fairness may be overcome by referring to another key value, that of collective responsibility. The present generation has the opportunity to start solving the problem and paving the way for



future generations to continue this work. Doing nothing can be seen as a choice that is not beneficial to future generations.

Openness, fairness and transparency are important requirements to achieve trust in the decision-making process. As discussed in Chapter 5, transparency means that it should be clear from the start who will take decisions, how decisions are made and who will be involved. Process rules, role clarity and a clear role division between all involved actors will contribute to this.

The decisions that are part of the decision-making trajectory towards a long term waste disposal as presented in the stakeholder workshop were recognizable for the stakeholders: choice about the radioactive waste fractions that should be disposed, selection of host rock and disposal concept, choice between a national or multinational disposal facility, specification of the role of retrievability in the decision-making process, specification of the role of participation in the decision-making process, specification of safety requirements and procedure to demonstrate the safety of the facility, and finally site selection.

One of the requirements for the decision-making process that came up in the interviews and stakeholder workshop is to involve sceptics or non-involved institutions in the decision-making process<sup>31</sup> as to watch over the process to prevent from ‘groupthink’. Stakeholders also emphasized the introduction of “checks and balances” in the decision-making trajectory as a way to deal with the issue of ‘groupthink’.

The absence of clear goals on the shorter term (i.e. the next decades) for the decision-making and RWM in general at this moment leads to disinterest and lack of attention of stakeholders for the topic. A broad engagement of stakeholders in workshops should therefore not be taken for granted. However, in line with general suggestions and voices picked up in the interviews and workshops, it is recommended to find a way to involve stakeholders as early as possible, and not only when major decisions need to be done. Then the question is: what is needed to involve the stakeholders in for instance research or dialogues? From the interviews and experiences in this project it is clear that some stakeholders don’t want to be involved as it is not attached to a concrete decision, and others could potentially be willing to contribute but will very critically review where they put their time in. Without clear set goals related to the decision trajectory it will most probably not be possible to engage all stakeholders in dialogues. When organising stakeholder dialogues the question what they get back from such an event (influence?, knowledge?, etc.?) as a ‘reward’ for investing their time will be very crucial for the decision of the stakeholders whether they will come or not.

#### 8.4.2. Potential stakeholder roles in decision-making

What are important pre-conditions or constraints for the stakeholders to involve them in the decision-making process and if they want to be involved, what kind of role do they want to play? In the workshops this was discussed.

Some of the environmental NGO’s indicate that a phase out of nuclear energy is a precondition for them to be involved in the decision-making process. The water supply sector indicates that their position is that they don’t allow any risk to groundwater.

<sup>31</sup>Institutions that have a societal role but do not take part in the decision-making process (for instance churches)

In the workshop stakeholders were asked what their preferred position was on “the ladder of participation” (see section 8.3.1, **Table 8-1**) for the decisions in the decision-making trajectory. Most stakeholders indicate that they want to be involved in the decisions of the long term decision-making trajectory. They differ concerning the preferred degree of involvement. A wide range from “information” to “taking a decision together” was scored on the ladder of participation, with a slight preference towards “advising”.

**Table 8-2: Indicated preferences of stakeholders for participation**

Information	Consultation	Advising	Co-producing	Co-deciding
15	18	33	11	13

This means that the involvement of stakeholders will require a tailor-made process, as there is no dominant preference for one of the categories of the ladder of participation. For the decision-making process this means that for each decision the level of stakeholder participation should be made very clear from the start and preferably should be discussed with the stakeholders. Transparency of the decision-making process is therefore needed, not only with respect to the main staging decisions as discussed in Section 3.2, but also with respect to all decisions behind RWM activities that are going to be made in the near future, including transparency on who is involved and in what manner.

The lack of clear targets for decision-making in the near future hampers the discussion now on how to organize a decision-making process and the related involvement of stakeholders. Some stakeholders want to discuss the decision-making for the geological radioactive waste disposal now, while for others there is no immediate cause to discuss this. There is a danger of losing time that is now available for a solid preparation of the decision-making process.

A strong supported advice from many stakeholders in the workshop was to take a decision about the decision-making process prior to the actual decision-making. This “decision about the decision-making” could be taken now and takes advantage of the given time period for the preparation of relevant decisions in future, in line with the preceding conclusion about transparency of the decision-making process. How this could be taken up is worked out as a recommendation (see Chapter 10).

## 9. Outline of a generic staged closure process in The Netherlands

In this chapter, an integrated description for an outline of a generic staged closure process in The Netherlands is given. Based on the considerations discussed in Section 9.1 and input from the in-depth interviews (Chapter 7) and the workshops (Chapter 8), in Section 9.2 a synthesis of the outline is presented for each stage in a narrative manner. In the last section, resulting key questions with respect to the outline are discussed.

### 9.1. Set-up of a staged process description

In this section, a conceptual generic staged closure process for a geological waste disposal facility in The Netherlands is elaborated in order to investigate potential options to implement reversibility, retrievability and staged closure, and to discuss the potential role of stakeholders in decision-making.

The main stages in disposal implementation and their characteristics have already been shortly reviewed in Chapter 3. The analyses in this section covers the period starting from the siting decision up to decision on final closure (Figure 9-1), and complements the discussion on stakeholder involvement in Chapter 5, mainly focusing on elaborating their principal roles in the different stages. This section provides a current state-of-the-art of international views, translated to the specific Dutch context. Based on the considerations discussed in this section, organizational aspects (Chapter 5.5), and input from the in-depth interviews (Chapter 7) and the workshops (Chapter 8), an integrated description for an outline of a generic staged closure process in The Netherlands is developed.

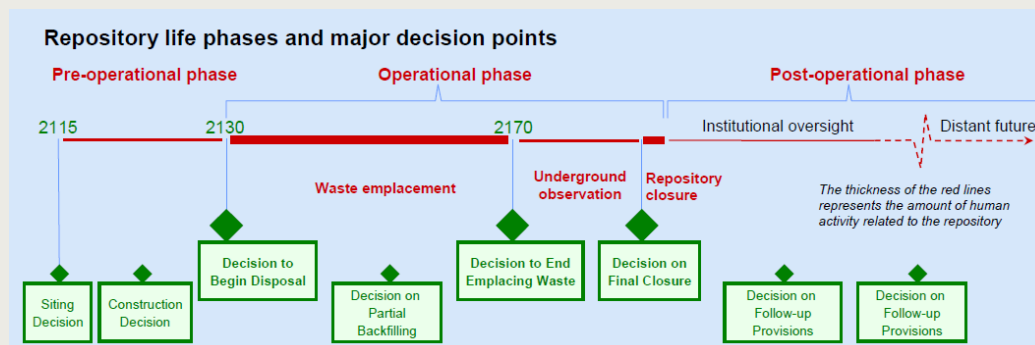


Figure 9-1: Repository life phases and major decision points for the OPERA reference concept [48]

#### 9.1.1. General considerations for the process development

Despite the straightforward description of the staged process as presented in Chapter 3 and the discussions summarized in that chapter, it should be evident that the principles of reversibility and retrievability are not well-defined concepts, and with stakeholders having varying expectations, meaning and role of these concepts should be clarified country specific [52, p.34].

In The Netherlands, while retrievability is seen as an essential part of the current RWM policy [19], no precise definition is given on how long retrievability has to be guaranteed, how it has to be implemented and what technical and financial efforts for retrieval are found acceptable [62]. Interviews with national experts have provided a first input regarding expectations on retrievability (Chapter 7). This topic was further discussed in a national stakeholder workshop (Chapter 8).

As will be elaborated below, the implementation strategy should consider a number of determinant and boundary conditions that will be sequentially discussed in subsequent subsections. These determinants and boundary conditions include:

- Technical, legal and logistic boundary conditions for the process;
- Future unknowns relevant for the process;
- The role or expectation of retrievability;
- Technical options for monitoring and role in the process;
- The role of reversibility in decision-making;
- Roles and responsibilities in the disposal process;
- The role of stakeholder participation and involvement.

In the next subsections, the first four aspects are shortly discussed, while the latter three aspects, discussed during the in-depth interviews and national stakeholder workshop, are addressed in Chapters 7, 8, and 10.

#### **9.1.2. Technical, legal and logistic boundary conditions**

A number of identified technical, legal and logistic boundary conditions relevant for the process description are discussed in this section:

- Legal requirements/national policy;
- Inventory of radioactive waste;
- Presence of suitable geological settings / Use of subsurface;
- Technical feasibility and long-term safety of a disposal facility;
- Costs.

##### **Legal requirements/national policy**

The principle roles and responsibilities were already discussed in Chapter 2.1. General features of the national policy on radioactive waste management specific to The Netherlands are:

- long-term interim storage before final geological disposal and build-up of sufficient funding during that period;
- requirement of retrievability of the waste;
- an implementation process that is currently less far developed than in other countries such as Sweden or Finland, with no detailed, explicit regulations existing;
- a principal interest in multinational solution, although currently the disposal of the waste is foreseen within the national boundaries.

##### **Inventory of radioactive waste**

The radioactive waste to be disposed is documented in the OPERA reports M1.1.1.A [116] and M1.1.1.B [117]. Notable here is that:

- The waste categorisation in The Netherlands does not distinguish between long- and short-lived LILW, and compared to other countries more fractions of the waste are foreseen for geological disposal. Decisions on different disposal options for different waste fractions may affect the cost for the disposal of individual waste fractions ('polluter pays'-principle), and may also be of relevance when considering a multinational solution.
- Relevant amounts of depleted uranium (DU) are foreseen for geological disposal.

- Currently all spent fuel from nuclear power plants (NPPs) is reprocessed and reprocessing waste is stored as vitrified waste. This could be relevant when considering later processing of the waste for any reason, e.g. by transmutation techniques.
- The length of the interim storage period affects the thermal heat dissipated by the HLW waste, which is a feature that influences the technical outline of a disposal concept and its safety assessment (i.e. a shorter interim storage period may result in the necessity to revise the disposal concept).

#### **Presence of suitable geological settings / Use of subsurface**

Presently, The Netherlands has investigated two potential host rocks more closely: rock salt and Boom Clay. Potential suitable regions of the latter more abundant than for the former, though less than was assumed until recently [118, 119]. No alternative host rocks have been assessed yet, although these are available (e.g. other clay layers). Only limited thoughts have been given to the future use of the subsurface for purposes that may compete with its use for disposal, e.g. storage of CO<sub>2</sub>, exploitation of shale gas, use of deep wells for drinking water, or use of geothermal energy.

#### **Technical feasibility and long-term safety of a disposal facility**

The general focus of the current OPERA research programme is the long-term safety. The technical feasibility has been looked at in the past (CORA) and with limited efforts (one work package) within the current programme, and might need more attention in one of the next research programmes. The planned Belgian Safety Case *SFC-1* might provide valuable information for the Dutch clay concept, too.

However, when considering a staged closure process, there should be a general agreement between the involved stakeholders that the proposed concept is safe and feasible before the operational phase can be started. Some of the underlying assumption, e.g. about host rock properties, should be confirmed during the construction, operational and closure phase. This information has to be included in (updated) safety cases.

#### **Costs**

In the past, a few cost studies have been performed. General line is that the fixed costs of a repository (i.e. not proportional to the amount to be stored) are high. This favours the disposal of all waste fractions in a single underground facility or (a) bi/multinational solution(s<sup>32</sup>) from an economic point of view.

##### **9.1.3. Future uncertainties**

Besides the request not to commit irreversibly to technical choices (see Section 2.1), an important drive behind the principles of reversibility and staged closure is to deal with uncertainties in the implementation of a geological disposal in the future. One aspect of uncertainty in decision-making is that for a complex problem as radioactive waste disposal, an iterative approach is necessary, because not all information on which decisions should be based is available beforehand. Some data can only be collected during the operational phase, by *in-situ* monitoring of host rock properties or by monitoring the evolution of relevant process parameters in time.

The principals of stepwise implementation and reversibility of decision-making as discussed in Chapters 3 and 4 may overcome this limitation to a certain extent, but it must also be acknowledged by all parties that decision-making on long-term complex projects has to

<sup>32</sup> for different waste fractions

deal with missing firm information as well as ongoing technical and societal developments. Most evident is this for the discussion on retrievability: here, further technical input is needed, in order to allow an useful, informed discussion [62] while in the current stage of RWM in The Netherlands it is probably too early to decide on a specific technical disposal concept and elaborate retrievability to a detail that allows to provide technical and experimental evidence on feasibility, its cost, risks, etc. over time.

One particular challenge is the introduction of additional uncertainties and added complexity to the process when works belonging to different stages are performed, overlapping or in parallel, in order to speed up the overall disposal process. This, however, is expected to be of less relevance in the Dutch case, where currently disposal is not foreseen before 2100.

Some uncertainties are linked to the simple facts that it is not possible to look into the future, or that decisions can only be made later on in the process. In case of The Netherlands, the following relevant uncertainties with respect to the definition of the staged closure process have been identified within the project:

- The inventory to be disposed can differ from what is assumed in OPERA: currently, only minor part of electricity production comes from NPPs, and although currently no new NPPs are in the planning, nuclear energy use might change in future.
- The waste fractions to be disposed in a geological facility may differ from what is assumed in OPERA: at this moment, almost all radioactive waste fractions are foreseen for underground disposal [48].
- A multinational cooperation might lead to lower or higher amount of waste, or different waste composition as is assumed in OPERA.
- As host rock, two types of formations considered are rock salt (Zechstein) and clay (e.g. Boom clay), but also others might be considered in future as well.
- The exact role of and expectations on retrievability are currently unclear.
- The extent of participation and partnership in the implementation process is unclear.

With respect to slightly altered waste composition or amount, one can assume that it will have no critical impact on the developed process description below. However, if the amount of waste increases significantly, or properties and composition deviate strongly, e.g. due to a future choice for a multinational facility, the process description would need to be re-evaluated.

The generic process description provided below focuses on a facility for disposal of radioactive waste, produced in The Netherlands, as drafted in [40] and [48]. In case of a bi- or multinational solution, decision-making will be more complex: if a common facility will be situated in The Netherlands, decision-making and participation processes should involve foreign partners. Likewise, the disposal of Dutch radioactive waste in a partnering country would raise the question in which way the Dutch government and stakeholders should participate in decision-making for a facility abroad. Although the relevance to gain more clarity on these aspects before aiming at a multinational solution is recognized, it goes beyond the scope of this study to analyse implications from a multinational cooperation in more detail.

It should also be noted that the descriptions provided below are limited to geological disposal and do not cover parts of the waste that might be decided to be disposed in near-surface disposals (e.g. short-living intermediate- and low-level waste). Because of the different features of such a facility, other approaches to management and decision-making are required.



#### 9.1.4. The role of retrievability

In Section 4.1.1 it was noted that a large number of reasons for retrieval can be given. Because not each objective is equally relevant with respect to the efforts, costs and (operational) risks that one may consider acceptable, for the purpose of the process description, two main groups of objectives are distinguished, based on their scopes and implications<sup>33</sup>:

- **Retrievability as management option:** The first three objectives in the list above have in common that they can potentially improve the long-term safety above the safety already provided by a disposal concept, or are related to other (e.g. economic) benefits. While it could make sense to enable current and future generations to re-evaluate previous RWM decisions, there is no strict necessity from safety point of view to do so: a disposal concept realized in line with the safety case methodology and general safety standards [13] represents a solution broadly accepted as safe by society. I.e. not considering these management options will have no adverse impact on the safety. Benefits, costs and risks of waste retrieval for these purposes should therefore carefully be weighed against each other.
- **Retrievability to assure safety:** In this case, retrievability is considered because of concerns that safety limits might be exceeded and a given, accepted safety standard cannot be guaranteed. This objective for retrieval is related to principle safety concerns. It must however be emphasized that disposal decisions will not be taken lightly with insufficient evidence for safety, trusting on the option of retrieval that allows to correct potential ‘mistakes’: there is a general agreement that safety should not rely on human intervention, but should be *passive*, and that the primary intention of geological disposal is a permanent emplacement of the waste ([60], §2.d). *Retrieval to assure safety* should therefore be regarded as *ultima ratio* to guarantee the safety of future generations.

At least for the first group of objectives, requirements on retrievability should be defined individually for each waste fraction, because features relevant for waste retrieval differ, e.g. with respect to radiotoxicity, number of containers, type and weight of the containers, matrix and waste composition (see Table 9-1). The vitrified HLW fraction for example consist of a small number of highly active waste containers, while LILW consist of a much larger number of containers with much less radiotoxicity per container. However, because the composition and properties of LILW container can be rather heterogeneous, it would also make sense to differentiate within this waste fraction, too, and dispose LILW containers that contribute most to the overall risk or that are more likely to be considered for alternative management options in future, in a way facilitating their retrieval.

If retrieval is considered for safety reasons, probably not all waste fractions, and probably not even all containers of a waste fraction need to be retrieved: also here, a differentiation between waste fractions and containers should be considered.

Finally, ease, cost and risk of waste retrieval may differ between different host rocks. This could lead to different requirements in different host rock, and the ease, cost of retrieval or related risks may provide a criterion to be considered for a future selection of the host rock.

<sup>33</sup>A more elaborated argumentation can be found in [62].

Table 9-1: Examples of waste fractions and their properties [based on [48]]

	Vitrified HLW	DU	LILW
number of containers	625	7,700	152,460
radionuclides	mixture	U <sub>3</sub> O <sub>8</sub> *	single nuclides or mixture
half-life	short to long	long	short to long
average radiotoxicity per container	33·10 <sup>6</sup> Sv	6,700 Sv	133 Sv
heat dissipation	yes	no	no
weight per container	20,000 - 24,000 kg	20,000 kg	<1,900 kg
matrix	glass	rather pure U <sub>3</sub> O <sub>8</sub> stabilized with concrete	varying types and composition of waste, partially stabilized with concrete
container	OPERA super container	cubic steel container	cylindrical steel container, partially with concrete shielding
estimated life time of the container**	1,000 -10,000 years	100 - 1,000 years	100 - 1,000 years

\* including ingrowth \*\*rough estimation, more precise numbers have to be established in OPERA

#### 9.1.5. Options for monitoring

The general benefits of monitoring are discussed in Section 4.1.3. Four principal options for monitoring can be distinguish in relation to the process definition:

- **In-situ monitoring:** here relevant parameter and features are monitored inside the disposal facility. The data can be used either as part of the licence application, or to support main assumptions underlying the safety assessments. Monitoring data can also contribute to decrease uncertainties. As discussed in Section 4.1.3, *in-situ* monitoring of disposal cells or behind other barriers can be challenging, because of the harsh environment conditions (radiation, pressure, heat), the requirement not to impair barrier functions and the inability to test or replace sensors.
- **Surface monitoring:** *surface monitoring* encompassed a variety of monitoring activities related to environmental monitoring (e.g. radionuclide concentrations in soil, water, air, plants etc.), monitoring related to constructional work (ground displacement, groundwater level, surveillance of excavated materials) or remote monitoring of the state of the underground facility (e.g. by micro-seismic measurements).
- **Long-term experiments in URLs:** long term *in-situ* experiments in URLs can provide evidence for safety. Because many processes of interest are rather slow, monitoring during the operational phase alone may yield insufficient data, especially in case the operational phase is rather short due to a limited amount of waste that needs to be disposed of. Long-term experiments in URLs, performed in a comparable environmental setting as the ‘real’ disposal, can be of interest in providing information in advance to the operational phase, and information that otherwise can only be achieved when *in-situ* monitoring is continued after all waste is emplaced, either by prolonging the operational phase or by considering post-closure monitoring.

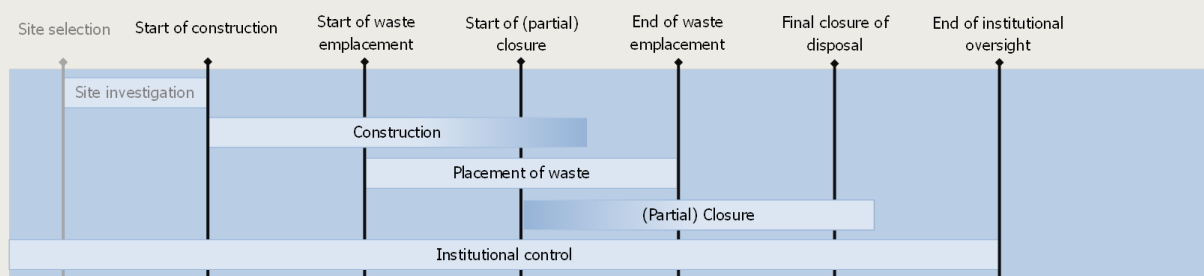
- **Monitoring in a ‘pilot facility’:** as discussed in Section 4.1.3, this kind of monitoring can complement long-term monitoring in URLs and *in-situ* monitoring.

### 9.2. Definition and description of stages

Several - slightly diverging - schemes and designations with respect to the indication of the *disposal stages* and *decision points* can be found in different projects and publications (compare e.g. Figure 3-1 and Figure 9-1). For the purpose of clarity in this section, an adapted scheme is used that distinguishes six *major decision points* indicated as follows:

- Start of construction;
- Start of waste emplacement;
- Start of (partial) closure;
- End of waste emplacement;
- Final closure of the disposal facility;
- End of institutional oversight.

Based on the stages and decision points depicted in **Figure 9-2**, in the following subsections the main characteristics of each decision point and the accompanying stages from construction to end of institutional control are shortly reviewed.



**Figure 9-2: Decision points and stages considered in this section**

#### 9.2.1. Early stages, prior to the construction

Although an analysis of the first stages is not in the scope of this report, a short description of the most critical milestones during this period is performed in this section, because relevant boundary conditions for the later phases are based on these early decisions. When a siting decision is considered, a number of decisions should have been taken (Section 3.2, see also [37]):

- Waste amounts and fractions that have to be disposed in a geological facility;
- Criteria for import of waste in case of a multinational repository;
- Selection of a host rock and a disposal concept;
- Criteria for site selection, including technical, logistic and societal aspects;
- A procedure for the selection of a host community;
- Potential compensation of host communities;
- Role of local partnerships<sup>34</sup> and other stakeholders in decision-making.

Based on the workshop discussion on earlier decisions, for national stakeholders an advising role in decision-making is most often mentioned (**Table 8-1**). However, for local stakeholders it can be assumed that their expected role in participation will expand to co-production and/or co-decision. While reversible decision-making was generally

<sup>34</sup> concerning the role of local partnerships see e.g. [52], p.21ff

acknowledged as a useful principle, it was mentioned in the workshop that there might be some risks related to the reversal of an earlier decision: this may lead to vague decision-making which may impair trust in the decision-makers and a higher financial risk. When a siting decision has to be made, financial and other concerns need to be answered, and a good balance between “robustness” and reversibility of decisions has to be found.

Besides the abovementioned principal decisions, a number of safety case components have to be available [37, 33], including:

- Establishment of formal regulatory approval for the selected site, a reference design and an application to start the construction phase;
- A site-specific environmental impact assessment;
- An approach to implement engineering solutions and monitoring techniques;
- Identification of site-specific key uncertainties;
- Establishment of regulatory limits;
- Identification of stakeholder expectations.

Prior to site selection, the characteristics of all candidate sites of interest must be investigated, including surface features and processes, geological setting, geochemical and hydrogeological properties, tectonic and seismic features as well as socio-economic factors such as local demography, land ownership and use, or road and rail infrastructure. An economic impact assessment has to be performed [49], and rules for economic compensation must be laid down. The process of site selection can be managed in a stepwise, iterative process that evaluates with increasing detail regional or local site properties, while establishing adequate local support for a disposal facility in the potential host communities. A voluntary siting process is expected to have much better chances to succeed [52, p.44], and once communities have applied for siting, additional site investigation is likely to be performed, before or after the siting decision (e.g. [49; p.182]). A local partnership may be established [52, p.44ff], and close communication and consultations between implementer and local representatives initiated.

Siting will implicate a number of agreements with the host community that could include aspect as:

- Waste amounts and properties of the waste to be disposed;
- Maximum operational period of the facility;
- Location, layout and purpose of surface facilities;
- Infrastructural measures to facilitate safe transport of the waste to the site;
- Environmental monitoring of surface site & surroundings and emergency plans;
- Plans for (surface) disposal of excavated materials;
- EIA for the operational phase;
- Role of (local) stakeholders in the decision-making bodies;
- Communication plan.

With respect to the purpose of the surface facilities, an important aspect is the (re)packing and conditioning of waste containers: the current disposal concept [48] foresees encasement of all HLW waste container by so-called ‘OPERA-super containers’ (Figure 9-3). Often national concepts foresee a waste conditioning facility on location, but repacking of the waste elsewhere might be considered, too. In case of The Netherlands all waste is stored at a centralized location (COVRA in Borssele), making the latter option more favourable than in countries where several interim storage facilities are present, located in different regions.



Figure 9-3: Artist impression of the OPERA supercontainer [48, p.15]

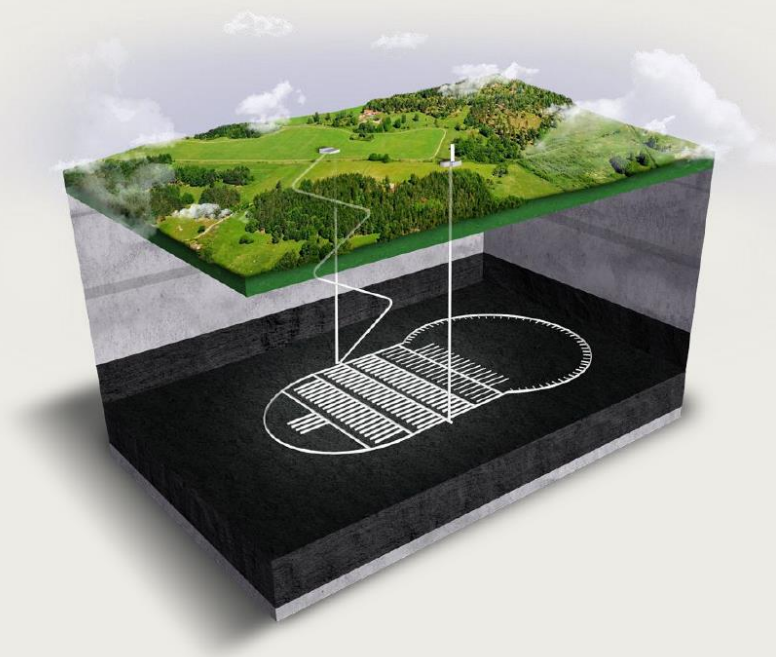
Once a decision on siting has been taken, additional, local data on the characteristics of the selected candidate site *in-situ* will be assessed to evaluate whether local host rock properties comply with the performance targets as identified in the safety strategy. Besides the use of remote techniques that are likely already applied prior to siting, additional geotechnical work will be performed in order to support the suitability of the selected location, e.g. by deep boreholes for sampling. Dependent on the disposal concept, the characteristics of the host rock can be more or less critical.

With respect to the role of local partnerships *after* siting selection, [52, p.43] emphasizes that:

*“Acceptance of the facility at a single point in time is not good enough. Successful disposal-facility siting implies creating the conditions for [...] the creation of conscious, constructive and durable relationships between the most affected communities and the waste management facility.”*

#### 9.2.2. Start of construction

When all additional information selected after the siting decision are within expectations, the safety case, disposal concept, and layout can be updated and a license application for construction can be submitted by the operator to the responsible regulator. Once the application is granted, in agreement with the local partnership constructional works can be started. This could also mean that the ability of the host community to withdraw their application will end.

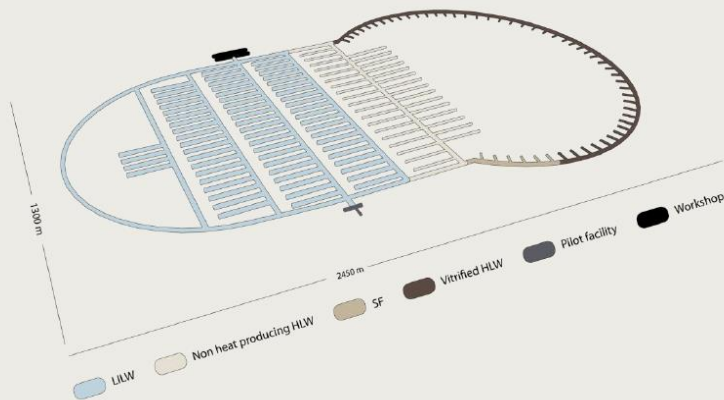


**Figure 9-4: Artist impression of a generic disposal concept in Boom Clay [48, p.11]**

A disposal facility consists of surface buildings, underground facility and access tunnels or shafts that connect aboveground and underground parts of the facility (Figure 9-4). The first important step will be the construction of an access to the host rock, i.e. a shaft or ramp. When the access to the host rock layer where the disposal will be situated is realized, a pilot facility can be implemented in order to allow collection of monitoring data from an early moment on (see Section 4.1.3). During construction of the main and secondary galleries (Figure 9-5, see also [48]), supporting information on the local properties of the host rock can be collected, resulting in a detailed overview on the host rock properties and features. Based on the collected information, minor changes in the disposal concept might be considered, e.g. small changes in the layout to avoid local heterogeneities of the host rock, or optimisation of the disposal or barrier concept<sup>35</sup>. All information collected during the construction phase has to be integrated in a location-specific update of the safety case. Changes in the disposal concept have to be communicated and discussed with the safety authority, and local partnerships have at least to be informed.

<sup>35</sup> It is likely that the original concept is based on over-conservative/worst case assumptions about the host rock properties.





**Figure 9-5: Artist impression of the circular main gallery, secondary galleries and waste disposal galleries of a generic disposal concept in Boom Clay [48, p.12]**

### 9.2.3. Start of waste emplacement

The *waste emplacement* phase starts when the first waste package is disposed of in the waste disposal sections of the underground facility (Figure 9-6) and represents a relevant milestone in the implementation process. A licence for disposal has to be granted by the safety authority, based on the updated safety case. The start of waste disposal does not necessarily have to wait until all construction work has been completed: the OPERA reference concept allows to establish radiological controlled zones, where radioactive waste is handled. These radiological controlled zones are separated from other parts of the facilities where construction works are taking place, but where no radioactive waste is handled. Both parts have a separate access to the underground facility. An early start of waste emplacement allows shortening of the period the facility is in operation.



**Figure 9-6: Artist impression of a waste disposal gallery of a generic disposal concept in Boom Clay [48, p.14]**

A decision must be made about the sequence in which the different waste fractions are disposed, which can be partially based on logistic aspects, e.g. transport of waste from COVRA to the disposal facility or repacking of the waste into the OPERA supercontainer [48], and partially on safety aspects - an early disposal of HLW allows to collect more monitoring data, while a late disposal might favour retrievability.

During the waste disposal, monitoring data will be collected and compared to expected values. In case of deviations, the cause will be analysed and the potential impact on the safety will be evaluated. The outcome will be communicated to the safety authority and

the local partnership. If safety analyses points to a relevant impact on safety, safety authorities, eventually supported by local partnership and other stakeholders will be consulted to discuss options and risks.

Although currently it is unclear under what conditions and to what extent retrievability is considered (at the stakeholder workshop it was mentioned that is it too early to discuss that), when waste is disposed, a clear decision should be available. The decisions should be based on detailed studies on feasibility, costs and risk of waste retrieval, supported by demonstration projects, preferably in-situ in an URL, providing additional evidence for the retrievability of the waste (see also [62]).

Because concerns about how one can be sure that all safety-relevant aspects are covered by safety studies are of principle nature, and thus cannot be answered incontrovertibly, it is realistic to expect from current point of view that retrievability of the waste will be considered within what is 'reasonably'<sup>36</sup> technically feasible. A possible future availability of technical solutions or developments that allow diminishing or reusing the waste was mentioned as an important reason for considering retrievability at the stakeholder workshop. When it will become more clear what is achievable during the (remaining) time of operation phase in a future disposal situation, during the course of disposal operation decisions concerning *retrievability as management option* could be updated, eventually leading to adaptations of disposal plans (e.g. early partial closure, see next section). Any relevant changes in operation need to be supported by an updated safety case and should be communicated and discussed with the safety authority and local partnerships.

#### 9.2.4. Start of (partial) closure

By partially backfilling of disposal galleries, secondary galleries or parts of the main gallery, sections of the disposal facility can be closed off and isolated from the rest of the facility. This may be performed for safety reasons, e.g. to minimize the number of affected disposal galleries in case of flooding related scenario's. However, each partial closure limits reversibility and increases the costs for retrieval of the waste. Besides, partial closure makes it more difficult to access part of the monitoring equipment, and may decrease the technical options for monitoring (see Section 4.1.3).

A decision for (partial) closure is based on an updated version of the safety case, that includes monitoring data collected during the operational phase, but may also be related to updated judgements on actual perspectives to diminish or reuse the waste (see previous section).

#### 9.2.5. End of waste emplacement

Because in The Netherlands, currently only a single disposal facility is foreseen, once it is decided that no more waste is disposed in the facility, all radioactive waste produced after that time must be disposed elsewhere<sup>37</sup>. However, such a decision does not mean that the facility is backfilled and closed immediately, as there might be reasons to wait before proceeding to final closure, as discussed in the next section.

The end of waste displacement can also be an important landmark for the local community: transport of radioactive waste will end, as will the conditioning and/or repacking of radioactive waste in the surface facilities.

<sup>36</sup> i.e. it includes some degree of subjectivity

<sup>37</sup> This aspect can be of importance for faster progressing countries. The relevance for a Dutch repository foreseen to operate until 2130 is currently unclear.

#### 9.2.6. Final closure of the disposal facility

Closure of the repository constitutes the final stage of the operational phase: the remaining open volumes will be backfilled and the access shafts or ramp will be sealed. After closure, no human intervention should be necessary in order to guarantee the safety of the facility in future. A decision for closure has two different facets: on the one hand, a timely closure may decrease potential risks considered in scenario studies (e.g. flooding by abandonment), and a short operational period with early closure can decrease disturbance of the host rock's natural state (e.g. oxidation, convergence), which might be favourable for the safety. On the other hand, after closure, reversibility is limited and retrievability will be significantly more costly because new shafts have to be excavated. Keeping a facility open longer also allows collecting and evaluation monitoring data over a longer time interval, which may give additional support to confidence in the long-term safety.

#### 9.2.7. End of institutional oversight

The period after closure of the facility is also called the *post-closure* period. All excavations have been backfilled and closed, and the disposal facility will no longer need any human intervention. Within the first part of this post-closure period, some kind of institutional control can be performed, e.g. by access control to the site or monitoring of the (sub)surface. Retrievability of the waste can be considered during that phase, supported by continued *in-situ* monitoring activities of an autonomous infrastructure in the sealed disposal that transmits monitoring results wirelessly to the surface [65, 120]. Eventually, the surface buildings of the facility can be decommissioned. At selected points in time it can be decided to either prolong or withdraw any further institutional control. This may depend on the public interest and ability in prolonged control, and may also be influenced by the state of monitoring equipment in the repository or data collected so far. Another important aspect when considering to extend the institutional control period is the presence (or absence) of the specific know-how that is needed to understand and interpret the meaning of monitoring results for the safety and their underlying scientific arguments.

At some point in time, however, further institutional control is expected to be withdrawn and a decision to end institutional oversight will be made. The period thereafter is called the *post-licencing phase*, because the responsibility of the operator and regulatory authority has ended. The decision of withdrawing institutional control thus implies that no operator and regulator are needed anymore. With respect to the preservation of human memory, knowledge and records, it is stated that this should be maintained by institutions, and it will be likely that the local community will have an important 'pragmatic' role [121]. It should be considered whether it is advisable to 'mark' the site for future generations or whether it would be safer to remove any hint on previous activities that may stimulate future generation to explore the underground. Like other decisions in this phase, the decision moment is far away in time, and depends strongly on societal developments difficult to predict. A decision will depend mainly on the attitude, values and technical options of future generations, and because in that stage no human intervention is expected to be necessary to guarantee the long-term safety of the facility, it is probably also unnecessary to give much guidance on that phase at this moment.

One aspect that needs to be considered in earlier phases of the implementation process is financial reservation that should be made to cover costs for monitoring, knowledge preservation and maintaining the technical abilities to reassess and judge the safety of the facility. More important in terms of total amounts are financial reservations that could be part of the retrievability requirement. Opinions about the necessity of such a reservation might differ; however, the end of institutional oversight means that any financial reservations are not administered anymore.

### *9.3.Key questions with respect to disposal implementation*

From the above description and analyses performed in [62], three key questions have been extracted that need to be answered during the course of the disposal implementation. These are shortly discussed below.

#### **9.3.1. Implementation of a voluntary siting process**

The societal and technical basis for site selection is discussed in Section 9.1 and 9.2.1. According to current views, siting should be done on a voluntary basis, leading to a local partnership. As discussed in the previous section, such a partnership will be based on agreements, e.g. about the amount, composition and origin of the waste to be disposed, or some indication of the period a facility will be in operation. However, it is important to understand that the current concept of reversible, staged closure might be at odds with the needs or preferences of a host community, that doesn't want to be confronted with too many uncertainties and open ends. As pointed out at the stakeholder workshop ([7]; Appendix 6), coming back to earlier decisions leads to vague decision-making or even "no decisions", which in turn can lead to diminishing trust. Because the host community's right of withdrawal has to be limited in some way - most likely withdrawal will only be possible until construction works begin, in the period thereafter, even if a right for veto in all consecutive decisions is granted, the host community will be saddled with the waste during the staged closure process that can last several decades. Thus, besides socio-technical selection criteria, also clear 'rules' for the engagement of potential host communities and other stakeholders and their roles in decision-making is needed. However, because after a siting decision the 'problem' is in some way transferred from national level to the host community<sup>38</sup> and any 'rules' or agreements affect the openness of the process and restrict options of later generations, it needs to be considered carefully which management options have to be settled in an early stage in the interest of the local partnerships.

#### **9.3.2. The meaning of retrievability**

While retrievability of waste is often seen as an important prerequisite, and such an option is considered beneficial in general, the technical consequences in terms of risks and costs have to be established in order to allow an informed discussion. However, while for national stakeholder retrievability is a question of values and preference, from point of view of a host community, retrievability has a more direct and practical implication: although the host community is expected to have relevant influence on decisions about different management options, retrievability is the only real 'opening' to reverse the disposal of the waste, and to prevent that the host community is saddled with the waste and accompanying risks. Such a decision is not taken lightly, and should involve a clear description of the scope of retrievability and clear rules about circumstances for which retrieval will be envisaged. Experiences from the German Asse II [122] shows that in case safety is impaired, stakeholders might favour the option of retrieval above other potential management options, even at high costs. Thus it is essential to clearly stipulate procedures, roles and the weight of a local partnership in such a decision.

Retrieval of the waste also requires some provisional plans where to store the waste until a new solution is found that can be realized in acceptable time, and financial reservations to allow retrieval start in time. Retrieval of the waste can result in an additional burden for the host community, e.g. due to temporary storage, processing and transport of the retrieved waste. In case retrieval of the waste is envisaged as management option<sup>39</sup>, it is

<sup>38</sup> while the legal responsibility will be of course still be borne by the government, the waste and all related hazards are accommodated at the host community

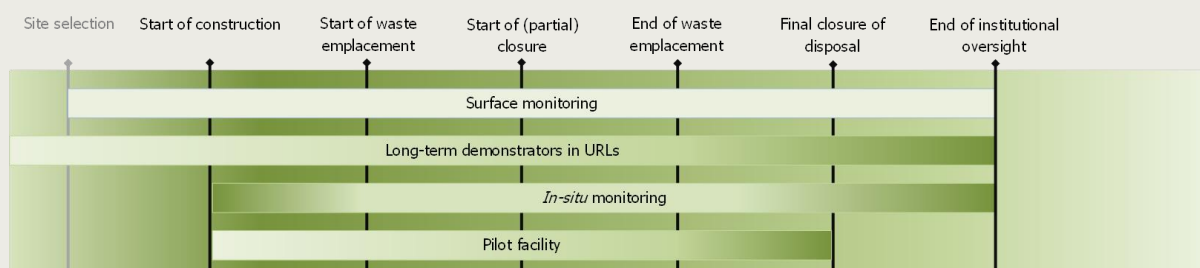
<sup>39</sup> i.e. because of the availability of techniques to minimize the lifetime or amount of the waste, or because part of the waste might be of economic value

realistic to expect that after waste processing some long-living residual remains that has to be disposed in a geological disposal. In that case, it must be clear whether such management decisions are covered by the siting agreement or not. Behind these questions hides also the more general question in how far the overall process with all its implications has to be predefined in advance, and in how far one can choose to leave such decisions to future generations.

### 9.3.3. Role of monitoring in the disposal facility, URLs and pilot facilities

One of the advantages of the Dutch policy on long-term interim disposal is that it allows collecting experimental evidence of safety relevant processes over longer time intervals by performing *in-situ* experiments and demonstrators at real scale, prior to the actual construction and operation of a final disposal facility. Long-term demonstration activities in URLs not only complement other monitoring activities (**Figure 9-7**), they might be a key element in building confidence and acquiring public acceptance for a disposal. These activities can provide supporting evidence long before disposal activities start, and the outcomes of such experiments could be used as relevant input for decision-making and may particularly be beneficial in support of a voluntary siting procedure. Long-term experiments can be performed in URLs, either in cooperation with other countries (e.g. the *HADES* URL in Belgium), or in a national facility. However, because these experiments are costly - certainly in case of the establishment of a national facility in The Netherlands - discussions are necessary on the relevance of long-term experiments and *in-situ* demonstrations, its role in the safety case and for decision-making. This includes discussions on the role of monitoring in general (linked to the previous sketched discussion on retrievability), the establishment of the technical feasibility of the intended activities, and its implementation in a future facility.

While a timely decision about the establishment of long-term demonstrators might be beneficial for the implementation process, prior to a larger (financial) engagement a selection of the host rock and a decision on the rules and roadmap for the implementation of a multinational solution (i.e. intended timeline, rules of cooperation) should be considered. Due to this link, it may be beneficial to clarify the role of monitoring and demonstrators in the Dutch RWM policy in near future.



**Figure 9-7: Monitoring activities during the different stages**



## 10. Recommendations

### 10.1. General remarks

In order to achieve the necessary degree of confidence, trust and support by societal groups, interactions with stakeholders and the general public are key determinants of a successful strategy for the implementation of a geological disposal facility<sup>40</sup>. CORA [24; p.10] stated that “*an acceptable solution for the waste problem will eventually only be achieved if, in a public debate, the societal and the technical aspects are considered on an equivalent basis*”. In addition to the support of the main objectives of geological disposal in general, as outlined in Section 2.1 of this report, the main purpose of stakeholder involvement is thus to increase confidence and broad-based societal acceptance of radioactive waste disposal.

In this chapter, practical recommendations to improve stakeholder engagement are given. These include topics like:

- which organisation is the responsible for initiating and implementing stakeholder interactions;
- who are the stakeholders that have to be involved;
- what actual activities need to be implemented;
- and what is the purpose of these stakeholder activities.

The recommendations are based on general guidance and international experience, translated to the national context of The Netherlands, reflecting many expert and stakeholder voices captured during the *ENGAGED* and *RESTAC* project.

With respect to guidance and international experience, for the sake of readability the use of references in this chapter is largely avoided, and the reader is referred to the principles discussed in Chapter 2 - 5. The abundant literature cited there provides useful guidance for any aspect encountered during the implementation of stakeholder engagement, and it is therefore recommended to use that resource as starting point.

With respect to the specific national context, it is recommended to take into account that the relevant ‘stakeholder scene’ is - like the nuclear programme of The Netherlands - very limited. It is expected that the number of stakeholder groups that may be involved in the near future - i.e. long before the first important decision point foreseen in 2080 - will be smaller than the number of stakeholder groups identified in Table 6-1. At present, the number of experts in The Netherlands with sufficient overview on the field of geological disposal of radioactive waste at the government, ANVS, COVRA, and scientific and consultancy organisations is small.

Pragmatical solutions for stakeholder engagement are important, and recognizing the limited resources, arrangements often seen as “successful” in other countries, may be less applicable in The Netherlands. However, while general principles as *transparency*, *openness* and *dialogue* should be leading also for The Netherlands, it needs to be understood that much of the guidance summarized in the first chapters of the present report (and in the cited literature) is based on experiences of countries with much larger nuclear programmes.

Of particular relevance in this context is also the acknowledgement of currently existing groups and fora: next to the involvement of some stakeholders in the *OPERA Safety Case*

<sup>40</sup>acknowledging that different, but rarely expressed views on this subject exist



group, the *OPERA steering committee* and the *OPERA advisory group*, the *NORA platform* represents an important stakeholder platform. Any stakeholder engagement could take the activities of these groups as a starting point.

As noted before, stakeholders can have different stakes. Of relevance here is e.g. that the research organisations TUD, NRG and ECN are also waste generators or owners. While it is obvious that these overlapping interests are not ideal with respect to the overall objective, i.e. increasing the confidence in safety, it should also be clear that this is the actual situation in The Netherlands that needs to be taken into account as given boundary condition. Again, transparency of roles and responsibilities of the involved groups is recommendable.

## 10.2. *Initiating stakeholder engagement*

What are the key features for a successful stakeholder engagement in The Netherlands on the short term, and how can such a stakeholder engagement be initiated?

The key messages of the *ENGAGED* and *RESTAC* projects with respect to these questions are threefold:

- Make use of the momentum created by the publication of the *OPERA Safety Case*
- Define clear targets for the coming 10 years and a general overall process outline for the years thereafter
- Communicate actively with stakeholders and the general public

### **Make use of the momentum created by the publication of the *OPERA Safety Case***

Different views exist on how much progress has to be achieved in the next decade. Stakeholders differ in their perception of urgency for a decision about geological disposal. Some want to start the discussion about this now, while others want to wait. With respect to political uncertainties and the long timescale of disposal implementation, it was questioned during the *ENGAGED/RESTAC* workshop whether postponing a decision to start the process towards siting in The Netherlands is positive or negative. On the one hand, it was noted that the risk of postponement is a loss of momentum, but on the other hand, it was acknowledged that the quality of decisions can benefit from having more time.

Some misperceptions exist concerning the timescales involved: implementation processes for geological disposal are generally slow, and it often takes a half century before the first waste containers can actually be disposed. This puts into perspective the period of 65 years until the first major decision is planned in The Netherlands into perspective, and shows that the concerns expressed on societal uncertainties in case of The Netherlands are equally valid for other, faster progressing countries.

Nevertheless, whatever the positions with respect to the necessity and urgency to engage with stakeholder are, the presentation of the *OPERA Safety Case* report planned for the second half of 2016 is a very suitable moment to actively start stakeholder engagement. In the last couple of years, several stakeholder interactions have taken place, either as part of the *OPERA* programme<sup>41</sup>, the preparation of the National Programme on radioactive waste management [5, 123], or activities around the *OPERA* programme (e.g. *NORA* workshops). Continuation of such engagement in following the completion of *OPERA Safety Case* report would prevent stakeholder feelings that they are asked to participate once in a time as a token of governmental interest in their position, while thereafter their engagement is of no (direct) consequence.

<sup>41</sup> i.e. activities summarized in this report

The remaining time until the presentation of the OPERA Safety Case report allows for careful preparation of subsequent engagement activities, including the exploration of preconditions and preferences of individual stakeholders for their engagement.

### **Define clear targets for the coming 10 years and a general overall process outline for the years thereafter**

The national policy on long term interim storage of radioactive waste raised the question: what has to be achieved in the near future that may motivate stakeholders to engage? The long-term interim storage policy of The Netherlands lacks a clear political roadmap for the implementation of geological disposal for the coming decades, which can be assumed to be major reason for the observed low interest in RWM of many stakeholders and the public in general. Consequently, there is presently no obvious societal urgency to develop a broader stakeholder dialogue or involvement activities nor to resolve existing different views or concerns of stakeholders as collected in [131] and partially still valid today.

Nevertheless, it is evident from the workshops that stakeholder involvement makes hardly sense without a clear roadmap on what has to be achieved in the next decades, because it give little cause for stakeholders to engage. A well-defined roadmap including clearly determined targets for 5 to 10 year intervals would likely motivate stakeholders to be more engaged in the process than is presently the case. Therefore it is recommended that the government sets clear targets for the coming years on<sup>42</sup>:

- **Process:** the decision and what it is about, the legal requirements, steps in the decision(-making) process, how is the decision made?;
- **Structure:** clear roles and responsibilities, who takes the decision?, which stakeholders to involve (in each step);
- **Behaviour:** transparency of the process, “process rules”;
- **Content:** relevant knowledge for the decision-making.

One primary objective or target for the coming 5 to 10 years could be to discuss a geological disposal as safest option on the long term: although deep geological disposal of radioactive waste as the safest option on the long term is official Dutch policy since more than three decades, it appears that not all stakeholders support that government position [124] and that relevant part of the general public are not convinced by this. In line with [18, 19, 20], a broad agreement regarding the long term disposal of radioactive waste as endpoint is expected to help focus discussions and could therefore be one of main objectives for a national roadmap.

### **Communicate actively with stakeholders and the general public**

To gain trust of citizens and the general public in the OPERA Safety Case, the proposed stakeholder participation is a first step. Equally important is the communication to a wide public, in order to increase confidence in the long-term safety of geological disposal. Communication with the general public about radioactive waste disposal is a challenging task, and will require relevant resources and commitment to be efficiently performed. The communication to a wider public requires a proper communication strategy: in the OPERA project *CIP* [39], general guidance on communication is given, and relevant determinants are discussed. It should be investigated which organisation should take the lead, how much resources are necessary, and who will provide these resources. The source of the communication should be preferably a joint effort of trusted institutions, a “composite body” [39; p. 13f].

<sup>42</sup>see also Table 5.2

Communication on radioactive waste should certainly include today's younger generation, because on the long term, that generation will be confronted with major decisions on radioactive waste disposal.

The concerns, thoughts, doubts, and perceptions registered in the project's expert interviews and stakeholder workshop (see [7], Appendix 4 and 6) can be of use when preparing the Safety Case report or other communication activities: The OPERA Safety Case and accompanying communication activities can actively address perceptions and concerns collected in these projects and other stakeholder interactions by marking them as relevant concerns to be addressed in future programmes, e.g. by assessing how societal and financial uncertainties over the long period of interim storage may affect the (long-term) safety (mentioned, but not sufficiently covered by [125]), by considering a scenario for terroristic attacks, or by calculating the influence of a repository on the water quality of deep groundwater wells at different position from the disposal site, in order to address concern of drinking water suppliers. While such a communication should fall into a general communication strategy, with preferably a "composite body" as source, any statements in the OPERA Safety Case should be aligned with the general communication strategy.

### 10.3. *Recommendations for stakeholder engagement in the next decade*

How can stakeholders be engaged, and what could be the objectives and purposes of stakeholder engagement?

Two options for engagement proposed by the stakeholders can be taken up for the short term: *develop a common knowledge base* and take a *decision about the decision-making process*. To make this work, the *government* should establish an appropriate framework in which the specific responsibilities with respect to stakeholder engagement for the regulator (ANVS) and the waste management organisation (COVRA) are clearly allocated (see Section 2.1), and a *Stakeholder Forum* should be established.

This leads to four recommendations for actions with respect to stakeholder engagement in decision-making, with the government, ANVS, and COVRA as responsible actors:

- Define clear responsibilities for COVRA & ANVS (government);
- Establish a stakeholder forum for "knowledge base" & definition of future research activities (ANVS or COVRA);
- Organize broader discussion on 'decisions on decision-making' (ANVS);
- Building and maintaining a knowledge base with stakeholder (COVRA).

These four recommendations are elucidated in the following paragraphs.

#### **Define clear responsibilities for COVRA & ANVS**

COVRA and ANVS have each their specific responsibilities: COVRA as waste management organisation and ANVS as regulatory body, and as independent administrative body of the Ministry of Infrastructure & the Environment (I&M), supporting development of the WM policy. However, with respect to the engagement of stakeholders, clear responsibilities are more difficult to define: one may regard stakeholder engagement and participation as part of policy development, which would make it task of ANVS. But one could also argue that engagement of stakeholders is an integral part of an implementation process, hence the task of COVRA. In any case, it is the responsibility of the government to clearly define the roles of ANVS and COVRA with respect to stakeholder engagement. A pragmatical approach should be followed, with available resources and expertise in mind. The government should also give a clear mandate for developing and eventually initiating a participative process.

### Setting up a Stakeholder Forum for “knowledge base” & definition of future research activities

The current OPERA Safety Case should be considered as a first step towards building a common knowledge base in a joint effort of COVRA, ANVS, experts, and other stakeholders, in line with requirements as documented in [10, 15, 37]. The accompanying OPERA research programme has taken concrete initiatives to investigate and define the societal embedding of the safety case by inventory how societal and stakeholder involvement may be shaped in the future, one of the questions of the research project documented in this report.

OPERA established several mechanism to integrate external expertise into the programme (e.g. the Safety Case Group, Technical Audits; see Figure 10-1) and to involve several stakeholders (Steering Group, Advisory Group), whereas the OPERA programme itself is the result of the activities of the NORA platform. It is recommended to continue these efforts to involve stakeholders in research activities in a more structured manner.

Different methods or approaches for stakeholder involvement are tested and discussed in RWM literature (e.g. *RISCOM II*), but other methods might be more appropriate for the specific purpose and boundary conditions in The Netherlands, e.g. ‘*joint fact finding*’ [126]. It will require the establishment of a *Stakeholder Forum*, and a sound and well-designed process with an independent process manager. This includes clear goals, roles, a working process, process rules, and conflict regulating mechanisms. Although it is up to the government to define a responsible actor, it seems more obvious that the ANVS should initiate and establish the Stakeholder Forum.

A Stakeholder Forum should be recruited from a wide range of stakeholders (see Chapter 6). For the short term, it could be considered to build upon existing stakeholder platforms, like NORA, other forums like for instance the stakeholder forum of the “Structuurvisie Ondergrond”, or combinations of these.

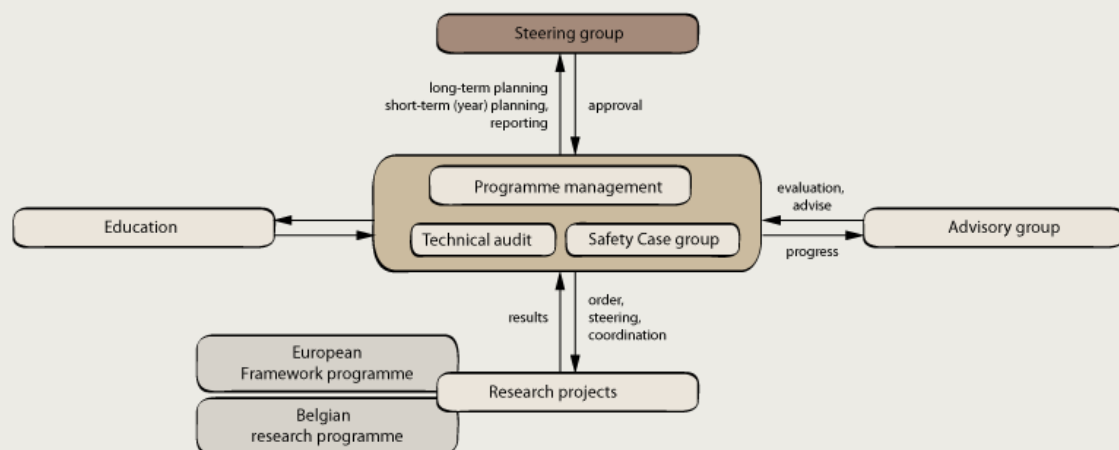


Figure 10-1: Structure of the OPERA programme [127]

One of the first objectives of the Stakeholder Forum could be to review and comment on the Safety Case report, and articulate new questions that should be answered. Important to note is, that asking stakeholders to articulate questions will imply at the same time that resources should be made available to answer these. Furthermore, the Stakeholder Forum

should be involved in the steps of the safety case that will follow after discussing the report, like discussing safety criteria that need to be developed. The two main activities of the Stakeholder are elaborated in the next paragraphs.

#### **Organise broader discussion on ‘decisions on decision-making’**

These idea of deciding about the decision-making process itself, brings a “sense of urgency” in the discussion, probably mobilizing the stakeholders, and prepares the decision-making about the geological disposal for the long term. It also offers the framework for developing a joint knowledge base. The preparation of the “decision about the decision-making process” could start soon, for instance with discussions with a wide range of stakeholder groups about the requirements and conditions for the decision-making process. In the “decision about the decision-making process” all important aspects for the decision-making process (how are decisions being prepared by whom?, who takes the decisions?, the process rules, the steps in the decision-making, the involvement of stakeholders in each step, responsibilities and roles of all involved actors) should be laid down, in line with recommendations by IAEA and NEA.

When such a decision (about the decision-making process) is taken by the national government, it also shows the commitment of the government to the decision process, which is an important signal to the stakeholders that their involvement really matters. The stakeholders consider it important that this decision is taken jointly by the government, the regulator, the waste management organisation and other stakeholders. In the stakeholder workshop this was called a *joint direction* over the process.

#### **Building and maintaining a knowledge base with stakeholders**

For any decisions about the development and implementation of a geological disposal an evidence-based policy-making process is required. Of particular relevance in developing a common understanding is the “robustness” of argumentation [131]. Therefore, a *knowledge base* is needed that is accepted and validated by the involved policy makers, experts, and stakeholders. Such a knowledge base could be closely related to the Safety Case, which contains all the information needed to proceed through a geological disposal programme, and must be updated synchronously. As for the safety case, the responsible actor for setting up and maintaining the knowledge base is the waste management organisation COVRA.

The ‘joint fact finding’ approach could already be applied to the outcomes of the OPERA Safety Case. As the research for the OPERA Safety Case has already started, the most ideal moment to start such a process (from the beginning) has passed. Nevertheless, a future suitable moment to initiate a stakeholder forum will be the publication of the final report on the OPERA Safety Case which is expected in 2016.

After that, periodic updates of the Safety Case are foreseen, so the process will continue after the OPERA Safety Case. Input for future research agendas may come from several sources: recommendations on basis of OPERA research (e.g. [128, 62]), review of recommendations of previous research programmes (e.g. [24]), the European research agenda [67, 129], analysis of stakeholder interactions (e.g. [5, 62, 131] and the present report) or the analysis of media monitoring [39]. A more direct, preferable approach is by involving stakeholders in joint fact finding, because building up the accepted and validated knowledge base requires an approach that goes beyond ‘listening’ to the concerns of the stakeholders, as is recommended for the ongoing OPERA Safety Case.

The ‘joint fact finding’ approach means that stakeholders will be involved from the very start in the research process, by designing research targets and priorities for future research efforts, valuating research results of completed projects and jointly formulating



recommendations. The overall objective of the safety case, to provide confidence in the long-term safety of geological disposal, includes several societal challenges. Questions related to stakeholder involvement or questions about decision-making contexts that will come up during the process should be accommodated in the following research programme, too. In the development process of the knowledge base, the stakeholders should, therefore, be asked to articulate their relevant questions and discuss these with researchers to translate these in research questions.

It should be noted again that without a clear link to explicitly defined medium-term objectives as part of the overall decision-making process (i.e. the “decision about the decision-making process”), this idea will lack urgency and probably suffer from lack of attention and disinterest.

The knowledge production side also needs attention as relevant expertise (on radioactive waste, related societal aspects, etc.) should be maintained and kept available for the future. Especially, the expertise on radioactive waste is scarce and should be maintained and kept sufficiently independent. There should be enough experts available on radioactive waste to review each other’s work critically. How both aspects - independency and the capacity for critical reviews - can be kept best in the future is out of the scope of this study and should be worked out further. Research programmes like OPERA can deliver resources to maintain the expertise, but improved continuity is needed (see Figure 2-2). Additionally, these type of programmes run over a limited period of time (4-5 years), while there is a clear need for long-term maintenance of expertise. Hence a clear roadmap should be developed that looks beyond the individual programmes.

#### 10.4. *Recommendations for stakeholder involvement on the long term*

For the long term decision-making trajectory, three points are important to consider, which are related to *handling of long term uncertainty, stakeholder involvement and knowledge management*.

The *uncertainty over long periods of time* (80-100 years) is very large, which means that in the meantime many things may change: institutions, stakeholder organisations, societal values, ways of governing, knowledge, technology, etc. This long term uncertainty is hard to capture and makes it hard to foresee whether decisions and actions will fit to future situations. The only strategy that will hold in such uncertain circumstances is an adaptive approach in the decision-making: update the decision about the decision-making (the process) periodically (for instance every 10 years) and assess whether the path forward should be changed or not. The principles of ‘stepwise decision-making’ over the long term and the ‘reversibility of decisions’ that are part of the RWM approach both fit this approach. Periodically, all aspects of the decision-making process and the common knowledge base should be reassessed: what has changed?, are there any new insights?, and what would this mean for the decision-making process? This repeated process enforces the learning process and builds the memory for the decision-making.

*Knowledge management* over such a long period of time is another point of concern, for which general guidance is given in [130]. The development of a joint knowledge base as mentioned in Section 10.3 is recommended as a good starting point: it can be a vehicle for continuous development of relevant knowledge on topics relevant for the decision-making trajectory on long-term disposal of radioactive waste. The close link between the joint knowledge base and the safety case and subsequent decision-making process will increase the urgency of knowledge management, which in its turn will provide focus and assure the necessary resources for knowledge management. The close link between the knowledge management system and a policy or decision-making process concerning long-term disposal of radioactive waste will facilitate maintenance of the system over the unavoidable longer



periods of time in which no relevant decisions will be made. Necessary resources need to be made available by COVRA or ANVS for developing relevant knowledge and for designing the appropriate processes for ‘knowledge sharing’ or ‘knowledge co-creation’ with stakeholders on the short term.

The *stakeholder involvement process* over the long term can be dealt with in a similar manner. Periodically (e.g. 10 years) an assessment should be made to determine whether new stakeholders should be involved in the process.

#### 10.5. *Implementation of an effective policy on retrievability*

Retrievability of the waste is an important requirement of the Dutch policy on radioactive waste disposal. However, as pointed out in the workshop, the concept of “retrievability” is insufficiently developed to allow a useful discussion with stakeholders. Based on this observation and further analyses, a number of recommendations is derived in [62], and summarized in this section:

- **Clarify the meaning of retrievability:** As pointed out in [62], although *retrievability* has been on the national agenda since 1984, in view of the ongoing development of RWM its current implementation is insufficiently developed to allow progress in the societal discussion. Rip et al. observed in [131] (see also [62]; Appendix E) that slightly different valuation of arguments pro or contra retrievability leads to different conclusions on the ability to dispose radioactive waste safely in the deep underground, with the proposed endpoints ranging from ‘no geological disposal’<sup>43</sup> over ‘use time of interim storage, but eventually proceed to geological disposal’ to ‘geological disposal’, either retrievable or (explicitly) non-retrievable. From the fourteen argumentation lines being developed, eleven are in some way related to retrievability, which underlines that retrievability is a major issue in RWM.

Clarifying the meaning and scope of ‘*retrievability*’ in an early stage is therefore expected not only to be helpful with respect to the specific topic, but also more general in bringing different stakeholders views closer together.

- **Distinguish between two main objectives for retrievability:** In [62] it is recommended to distinguish between ‘*retrievability as management option*’ and ‘*retrievability to assure safety*’. Focus of discussion should be on ‘*retrievability to assure safety*’, while discussion on ‘*retrievability as management option*’ can be postponed to later stages. Furthermore, it is recommended to distinguish in further investigations and discussions retrievability of different waste fractions.
- **Consider the option of retrievability in the post-closure phase as alternative for a prolonged pre-closure phase:** The discussion on retrievability should not be limited to the pre-closure phase, but should include the post-closure phase, too. When technology allows to monitor and retrieve the waste in the post-closure phase [132, 133], often decisive concerns [134] with respect to costs and risks related to increased operational periods can be addressed.
- **Consider options for retrievability from the point of view of a future host community:** Options for retrievability should be considered from the perspective

<sup>43</sup> in some case ‘no solution at all’

of a future host community, acknowledging that interest of yet unknown communities and unborn stakeholders has to be guaranteed.

- **Perform integrated socio-technical analyses and provide robust input for the discussion on feasibility, risk and benefits of retrievability:** While the advantages and disadvantages of retrievability were generally acknowledged, a consensus on the extent and role of retrievability is difficult to achieve, partially due to different preferences or values given to various arguments, but also because of insufficient insight on main questions: what are the costs of retrieval; what are the risks related to retrieval; what are exactly the technical options for surveillance and retrieval? An interesting interdisciplinary approach to address part of the questions discussed in [62] is followed in the recently started German research project ENTRIA<sup>44</sup> [135, 136]: here, three options of interest in the public discussion are investigated, covering all endpoints elaborated in [131] (“vertical projects”), while at the same time, three “transversal” interdisciplinary projects are performed (Figure 10-2). Such an approach might allow independent technical and interdisciplinary research and might provide more insight in societal acceptance of the different disposal options.

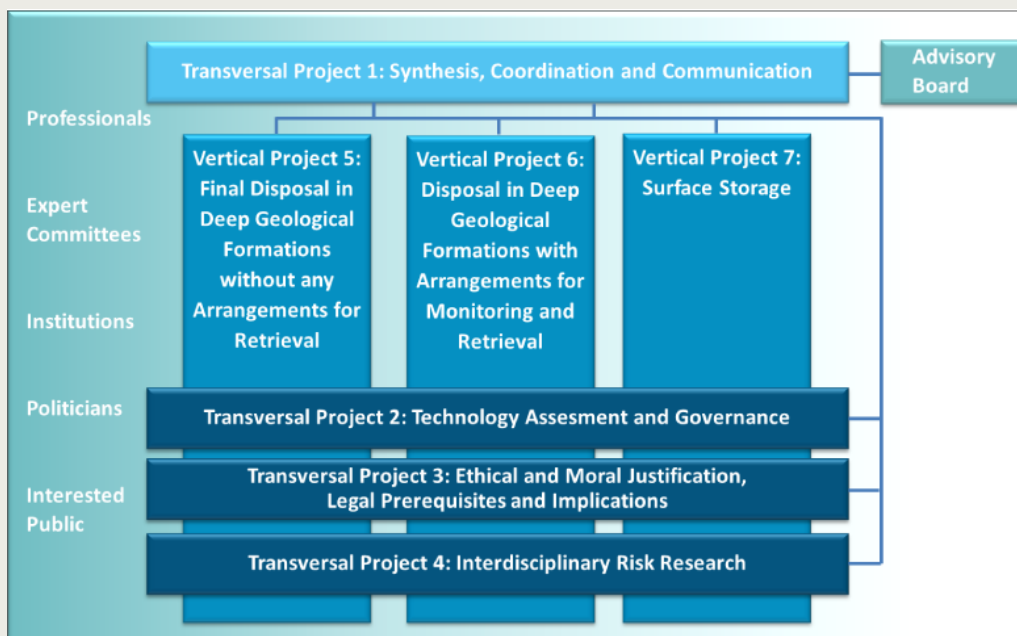


Figure 10-2: Overall structure of the *ENTRIA* project [135]

- **Clarify the requirements on retrievability before a selection procedure for a technically disposal concept is initiated:** It is recommended that a selection procedure for a technically disposal concept should include the retrievability of a container design as an important criterion. The topic of retrievability should be elaborated in sufficient detail *before* technical disposal concepts are selected and costly technical investigations are performed.
- **Consider the level of retrievability and surveillance as criteria for host rock selection:** Of somewhat lesser urgency for the vision on retrievability is the link to

<sup>44</sup> “Disposal Options for Radioactive Residues: Interdisciplinary Analyses and Development of Evaluation Principles” (“Entsorgungsoptionen für radioaktive Reststoffe: Interdisziplinäre Analysen und Entwicklung von Bewertungsgrundlagen”)

retrievability and surveillance as criteria for host rock selection: the ‘level’ of retrievability and surveillance that is offered by a host rock might be an important criterion in the future selection of the host rock.

- **Elaborate the role of monitoring for decision-making:** In addition to European research on the topic [61, 63, 65, 66, 137] additional efforts are necessary to explore the specific options and possible benefits that are available due to the long-term storage policy of The Netherlands, which are of lesser relevance for the larger nuclear countries dominating the European research agenda.
- **Develop a clear position on the role of Underground Research Laboratories:** The Dutch policy on long-term interim storage allows performance of experiments over relevant time periods *in advance* of siting or construction decisions. Due to the long timeframe, the role of experimental confirmation of key processes in URLs can be much larger than in other programmes where monitoring activities during the operational period of a disposal facility have an important role. In [62] it is therefore recommended to develop a clear position on the role of long-term experimental and demonstration work in URLs as part of the safety case. Next to the position regarding a (future) national URL, in the near future also cooperation with other European partners should be considered, e.g. Belgian experiments being performed in the HADES URL (Mol) in Boom Clay, or future activities in rock salt in Germany.

## 11. References

- [1] ENGAGED, *Proposal for WP1.2: Political requirements and social expectations*, OPERA-PG-COV010, ECN/TNO/NRG, March 2012, 1-21.
- [2] RESTAC, *Retrievability and staged closure; Proposal for OPERA Task 1.2.3*, OPERA-PG-COV017, ECN/TNO/NRG, July 2012, 1-19.
- [3] Verhoef, E, TJ Schröder, *OPERA Research plan*, OPERA-PG-COV004, COVRA N.V., 2011, 1-48.
- [4] Centrale Organisatie Voor Radioactief Afval (COVRA), *OPERA publicaties / CORA research reports*, <http://www.covra.nl/downloads/opera>
- [5] Vries, A. de, Waes, A. van, Est, R. van, Meulen, B. van der, Brom, F., *Enabling participation - A vision on public participation in decision-making about long term radioactive waste management*, Rathenau Institute, 2015, 1-68.
- [6] Börjeson, L., Höjer, K. Dreborg, H., Ekvall, T. and Finnveden., G. (2006), "Scenario types and techniques: Towards a user's guide", *Futures* 38, 723-739.
- [7] Mozaffarian, M. (ed.), S Brunsting, E Luken, JCM Uytterlinde, A Slob, T Geerdink, TJ Schröder, BRW Haverkate, S Breukers: Stakeholder engagement in the implementation of a geological disposal for radioactive waste, OPERA report OPERA-PU-ECN121 (appendices), November 2015, 1-74.
- [8] Schröder, TJ, BRW Haverkate, Interim list of recommended reference values for safety indicators, OPERA report OPERA-IR-NRG1221, September 2014, 1-8.
- [9] International Atomic Energy Agency (IAEA), *The Principles of Radioactive Waste Management*, Safety Series No. 111-F, IAEA, Vienna (1995), 1-24.
- [10] International Atomic Energy Agency (IAEA), *Fundamental Safety Principles, Safety Fundamentals*, No. SF-1, IAEA Safety Standards for protecting people and the environment, Vienna, 2006, 1-21.
- [11] International Atomic Energy Agency (IAEA), *IAEA Safety Standards: Radioactive Waste Disposal Facilities*, <http://www-ns.iaea.org/standards/documents/default.asp?s=11&l=90&sub=40&vw=9#sf>.
- [12] Nuclear Energy Agency (NEA), *A Common Objective, a Variety of Paths. Third international conference on Geological Repositories*. Berne, Switzerland, 15-17 October 2007. NEA report 6875, OECD, Paris, 2009, 1-125.
- [13] International Atomic Energy Agency (IAEA), *Geological disposal of radioactive waste*. IAEA Safety Requirement no. WS-R-4, IAEA, Vienna, 2006, 1-49.
- [14] International Atomic Energy Agency (IAEA), *Establishing and National System for Radioactive Waste Management*, Safety Series No. 111-S-1, Vienna 1995, 1-28.
- [15] International Atomic Energy Agency (IAEA), *Disposal of Radioactive Waste, Specific Safety Requirements*, IAEA Safety Standard Series No. SSR-5, Vienna, 2011, 1-62.
- [16] International Atomic Energy Agency (IAEA), *Policies and Strategies for Radioactive Waste Management*, IAEA Nuclear Energy Series No. NW-G-1.1, VIENNA, 2009, 1-68.
- [17] Nuclear Energy Agency (NEA), 2004, *Stepwise Approach to Decision- Making for Long-term Radioactive Waste Management. Experience, Issues and Guiding Principles*, OECD/NEA report no. 4429, NEA, Paris, 1-72.
- [18] Ministry of Housing, Spatial Planning and Environment (VROM), *Radioactive waste policy in The Netherlands; An outline of the Government's position*, 's-Gravenhage, September 1984, 1-21.
- [19] Ministry of Housing, Spatial Planning and Environment (VROM), *Kabinetsstandpunt over de vraag of de diepe ondergrond mag en kan worden gebruikt voor het opbergen van afval*, Letter of the Minister van de Minister of Housing, Spatial Planning and Environment to the Lower House, Plenary Year 1992-1993, 's-Gravenhage, 14 May 1993, 1-10.

- 
- [20] Ministry of Housing, Spatial Planning and Environment (VROM), *Beleidsstandpunt onderzoek radioactief afval*, Letter of the Minister of Housing, Spatial Planning and Environment to the parliament, budget year 2002-2003, 28 674, 's-Gravenhage, 11 November 2002, 1-15.
  - [21] Technische Commissie Bodembescherming (tcb), *Advies toetsingskader en IBC-criteria lokale bodemverontreiniging*, tcb report TCB A90/O1, Leidschendam, december 1990, 1-90.
  - [22] Ministry of Economic Affairs, Agriculture and Innovation, Ministry of Foreign Affairs, *Joint convention on the safety of spent fuel management and on the safety of radioactive waste management. National Report of the Kingdom of The Netherlands*. Fourth review conference (May 2012), The Hague, September 2011, 1-148.
  - [23] Official Journal of the European Union, *Council Directive 2011/70/EURATOM Of 19 July 2011; establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste*, 2.8.2011, L 199, p. 48-56.
  - [24] Commissie Opberging Radioactief Afval (CORA), *Terugneembare berging, een begaanbaar pad? Onderzoek naar de mogelijkheden van terugneembare berging van radioactief afval in Nederland*, Ministry of Economic Affairs, The Hague, February 2001, 1-110.
  - [25] Commissie Opberging te Land (OPLA), *Onderzoek naar geologische opberging van radioactief afval in Nederland. Eindrapportage Fase 1*, Ministry of Economic Affairs, The Hague, May 1987, 1-21.
  - [26] Prij, J, BM Blok, GMH Laheij, W van Rheenen, W Slagter, GJM Uffink, P Uijt de Haag, AFB Wildenborg, DA Zandstra, *PROSA: PRObabilistic Safety Assessment. Final report*, ECN, Petten, November 1993.
  - [27] Barnichon, JD, B Neerdael, J Grupa, A Vervoort, *CORA project TRUCK-II*, SCK-CEN report R-3409, Mol, January 2000, 1-75.
  - [28] Verhoef, E, E Neeft, *Towards a safety strategy. Developing a long-term Dutch research programme into geological disposal of radioactive waste*, OPERA report OPERA-PG-COV014, March 2014, 1-20.
  - [29] Nuclear Energy Agency (NEA), *The Nature and Purpose of the Post-closure Safety Cases for Geological Repositories*, NEA report 78121, OECD, 2013, 1-53.
  - [30] Andra, *Dossier 2005 Argile. Synthesis. Evaluation of the feasibility of a geological repository in an argillaceous formation*. Meuse/Haute-Marne site, Andra report series, December 2005, 1-239.
  - [31] NAGRA, *Projekt Opalinuston: Synthese der geowissenschaftlichen Untersuchungsergebnisse. Entsorgungsnachweis für abgebrannte Brennelemente, verglaste hochaktive sowie langlebige mittelaktive Abfälle*, NAGRA Technischer Bericht 02-03, 2002, 1-659.
  - [32] Svensk Kärnbränslehantering AB (SKB), *Long-term safety for KBS-3 repositories at Forsmark and Laxemar - a first evaluation*, Main Report of the SR-Can project, SKB Technical Report TR-06-09, October 2006, 1-620.
  - [33] Hart, J, P Davis, D-A Becker, U Noseck, L Hendriksen, AFB Wildenborg, M Winegram, *Evaluation of current state-of-the art on Safety Case methodologies*, OPERA report OPERA-PU-NRG211A, January 2014, 1-235.
  - [34] Nuclear Energy Agency (NEA), *Confidence in the Long-term Safety of Deep Geological Repositories. Its Development and Communication*, OECD, Paris, 1999, 1-80.
  - [35] Hart, J, P Davis, D-A Becker, U Noseck, L Hendriksen, AFB Wildenborg, TNO, M Winegram, *OSCAR. Evaluation of current state-of-the art on Safety Case methodologies*, OPERA Deliverable M2.1.1.a. OPERA Report OPERA-CF-NRG211A, December 2012, 1-209.



- 
- [36] Grupa, JB, P Davis, *Report on the OPERA Safety Case structure*, OPERA report OPERA-PU-NRG008, October 2013, 1-24.
  - [37] International Atomic Energy Agency (IAEA), *The Safety Case and Safety Assessment for the Disposal of Radioactive Waste*, Specific Safety Guide No. SSG-23, IAEA, Vienna, 2012, 1-120.
  - [38] Radioactive Waste Management Committee/Integration Group for the Safety Case (IGSC), *Consideration of timescales in post-closure safety of geological disposal of radioactive waste*, NEA report 6424, 2009, 1-159.
  - [39] Jelgersma, E, TJ Schröder, *Interim report on communicating Safety Case results*, OPERA report OPERA-IR-NRG131A, May 2014, 1-79.
  - [40] Verhoef, E, OPERA Meerjarenplan. OPERA report OPERA-PG-COV002, COVRA N.V., July 2011, 1-22.
  - [41] NRG, TNO, GRS and EnviroLogic, *OSCAR - Task 2.1.1. Structure of the OPERA Safety Case (OSC) Sub-task B: the OPERA Safety Case structure. Draft Version*, OPERA Report M2.1.1.b, March 2013, 1-57.
  - [42] Verhoef, E, *Status of OPERA*, presentation at the 1<sup>st</sup> OPERA Expert meeting, Nieuwdorp, 12 September 2012.
  - [43] Centrale Organisatie Voor Radioactief Afval (COVRA) N.V., OPERA. *OnderzoeksProgramma Eindberging Radioactief Afval*. Project Contract.
  - [44] International Atomic Energy Agency (IAEA), *PRISM project page*, <http://www-ns.iaea.org/projects/prism/default.asp?s=8&l=67>
  - [45] Hart, J, J Prij, G-J Vis, D-A Becker, J Wolf, U Noseck, D Buhmann, *Collection and analysis of current knowledge on salt-based repositories*, OPERA report OPERA-PU-NRG221A, July 2015.
  - [46] Heijdra, JJ, J Prij, *Concept ontwerp terughaalbare berging in steenzout: eindrapport METRO 1*, ECN report C 96 087, Petten, 1997, 1-25.
  - [47] Van der Steen, B, A Vervoort, *Mine Design in Clay. CORA project TRUCK-I*, CORA report 98-46, Catholic University of Leuven, Belgium, 1998, 1-109.
  - [48] Verhoef, E, E Neeft, J Grupa, A Poley, OPERA. *Outline of a disposal concept in clay*, OPERA report OPERA-PG-COV008, COVRA N.V., November 2014, 1-20.
  - [49] The West Cumbria MRWS Partnership, *The Final Report of the West Cumbria Managing Radioactive Waste Safely Partnership*, Copeland Borough Council, United Kingdom, August 2012, 1-274.
  - [50] Van der Linden - Engeltjes, ND, JB Grupa, *Kosten van een opbergfaciliteit in een kleiafzetting, TRUCK\_NB project*, NRG report NRG-22151/11.111590, NRG, Petten, December 2011, 1-30.
  - [51] Nuclear Energy Agency (NEA), *Selected international bibliography on reversibility and retrievability to support the current NEA project*, NEA report NEA/RWM(2010)11, September 2010, 1-15.
  - [52] Nuclear Energy Agency (NEA), *Stakeholder Confidence in Radioactive Waste Management. An Annotated Glossary of Key Terms*, NEA report 6988, OECD/NEA, Paris, 2013, 1- 64.
  - [53] Grupa, JB, DH Dodd, JM Hoorelbeeke, B Mouroux, JM Potier, J Ziegenhagen, JL Santiago, J Alonso, JJ Fernandez, P Zuidema, IG Crossland, B McKirdy, J Vrijen, J Vira, G Volckaert, T Papp, C Svemar, *Concerted action on the retrievability of long-lived radioactive waste in deep underground repositories. Final report*, Nuclear science and technology series EUR19145 EN, European Communities, Luxembourg, 2000, 1-290.
  - [54] Nuclear Energy Agency (NEA), *Reversibility of Decisions and Retrievability of Radioactive Waste. Considerations for National Geological Disposal Programmes*, NEA report 7085, OECD/NEA, Paris, 2012, 1-27.



- 
- [55] Beckmann, K, J Feinhals, S Heinzl-Große, A Hucke, N Kohl, J te Kook, C Löffler, C Scior, D Walbrodt, D Wittenberg, *Beurteilung der Möglichkeit einer Rückholung der LAW-Abfälle aus der Schachtanlage Asse*, DMT & TÜV Nord, 2009, 1-350.
  - [56] Nuclear Energy Agency (NEA), NEA Leaflet R scale, 1-4.
  - [57] Nuclear Energy Agency (NEA), Reversibility and Retrievability in Planning for Geological Disposal of Radioactive Waste, Proceedings of the R&R International Conference and Dialogues, 14-17 December 2010, OECD/NEA, Reims, France, 2012, 1-234.
  - [58] Nuclear Energy Agency (NEA), *More than Just Concrete Realities: The Symbolic Dimension of Radioactive Waste Management*, NEA report 6869, OECD/NEA, Paris, 2010, 1-34.
  - [59] Nuclear Energy Agency (NEA), *Learning and Adapting to Societal Requirements for Radioactive Waste Management. Key findings and experiences of the Forum on Stakeholder Confidence*, NEA report 5296, OECD/NEA, Paris, 2004, 1-67.
  - [60] International Atomic Energy Agency (IAEA), *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, INFCIRC/546, December 1997, 1-32.
  - [61] NDA, Nagra & NRG (eds.), *MoDeRn Monitoring Reference Framework report*, MoDeRn Deliverable D-1.2, November 2013, 1-73.
  - [62] Schröder, TJ, BRW Haverkate, ABF Wildenborg, *Topic report on retrievability, staged closure and monitoring*, Draft OPERA report OPERA-PU-NRG123, 4 August 2015, 1-83
  - [63] White, MJ, *Monitoring During the Staged Implementation of Geological Disposal: The MoDeRn Project Synthesis*, MoDeRn Deliverable D-6.1, January 2014, 1-90.
  - [64] AITEMIN, *Technical requirements report*, MoDeRn Deliverable D-2.1.1, January 2011, 1-52.
  - [65] AITEMIN, NDA, Andra, NRG, Nagra, Enresa, EURIDICE, ETH Zurich, NRG, RWMC, DBE-TEC, Posiva, SKB, RAWRA, GSL, *State of Art Report on Monitoring Technology*, MoDeRn Deliverable D-Nº: 2.2.2 , May 2013, 1-217.
  - [66] Jobmann, M (ed.), *Case Studies. Final Report*, MoDeRn Deliverable D-4.1, October 2013, 1-143.
  - [67] Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP), Strategic Research Agenda 2011, July 2011, ISBN 978-91-979786-0-6, 1-65.
  - [68] ESV Euridice, *HADES, the focus of the ESV EURIDICE infrastructure*, <http://www.euridice.be/eng/010301infrastructuur.shtm>.
  - [69] Nuclear Energy Agency (NEA), *Cultural and Structural Changes in Radioactive Waste Management Organisations. Lessons Learnt*, NEA report NEA No. 6180, OECD, 2007 ,1-43.
  - [70] Nuclear Energy Agency (NEA)/ Forum on Stakeholder Confidence (FSC), *Stakeholder involvement in radioactive waste management decision-making. Annotated Bibliography*, NEA report NEA/RWM/R(2015)4, 2015, 1-27.
  - [71] Cuppen, E. (2009), *Putting Perspectives into Participation. Constructive Conflict Methodology for problem structuring in stakeholder dialogues*, Oisterwijk: BOXPress.
  - [72] Luhmann, N. (1993), *Risk: A sociological theory*, New York: Walter de Gruyter.
  - [73] Bergmans, A. (2008), *Meaningful communication among experts and affected citizens on risk: challenge or impossibility?*, Journal of Risk Research, 11:1, 175-193.
  - [74] Laermans, R. (1999), *Communicatie zonder mensen. Een systeemtheoretische inleiding in de sociologie*, Amsterdam: Boom.
  - [75] Department of Energy & Climate Change, *Implementing Geological Disposal, A Framework for the long-term management of higher activity radioactive waste*, Governmental White Paper URN 14D/235, United Kingdom, July 2014, 1-54.

- 
- [76] English, MR, *Who are the Stakeholders in Environmental Risk Decisions?* In: Nuclear Energy Agency (NEA), Stakeholder confidence and radioactive waste disposal. Inauguration, First Workshop and Meeting of the NEA Forum on Stakeholder Confidence in the Area of Radioactive Waste Management, Paris, France, 28-31 August 2000, p.99-104.
  - [77] United Nations Economic Commission for Europe (UNECE), *Convention on access to information, public participation in decision-making and access to justice in environmental matters, done at Aarhus, Denmark, on 25 June 1998*, 1998, 1-25.
  - [78] United Nations (UN), *Convention on environmental impact assessment in a transboundary context*, 1991, 1-22.
  - [79] Nuclear Energy Agency (NEA), *Dealing with Interests, Values and Knowledge in Managing Risk*. Workshop Proceedings, Brussels, Belgium 18-21 November, 2003, NEA report NEA No. 5301, 2004, 1-168.
  - [80] Breman, B., Pleijte, M., Ouboter, S., Buijs, A., *Participatie in waterbeheer, Een vak apart*, november 2008, 1-216
  - [81] Nuclear Energy Agency (NEA), *The evolving role and image of the regulator: trends over two decades*, NEA report NEA/RWM/RF(2012)1/FINAL, NEA, Paris, 26-Apr-2012, 1-20.
  - [82] website of the CiP project (Community Waste Management In Practice), <http://www.cowam.com/>
  - [83] Martell, M, I Kopetz, D Russi, OBRA. European Observatory for long-term governance on radioactive waste management, Publishable final Activity Report (D5.4), December 2008, 1-18.
  - [84] website of the ARGONA Project (Arenas for Risk Governance), <http://www.argonaproject.eu>
  - [85] Andersson, K, M Westerlind, E Atherton, F Besnus, S Chataignier, S Engström, R Espejo, T Hicks, B Hedberg, J Hunt, A Laciok, A Leskinen, C Lilja, M O'Donoghue, S Pierlot, C-O Wene, J Vira, R Yearsley, *Transparency and Public Participation in Radioactive Waste Management. RISCOM II Final report*, SKI Report 2004:08, SKI, Stockholm, October 2003, 1-115.
  - [86] website of the IPPA Project (Implementing Public Participation Approaches in Radioactive Waste Disposal), <http://www.karita.se/projects/the-ippa-project.php>
  - [87] Nuclear Energy Agency (NEA), *Stakeholder Involvement Techniques. Short Guide and Annotated Bibliography*, NEA report NEA No. 5418, OECD, 2004, 1-50.
  - [88] Nuclear Energy Agency (NEA)/ Forum on Stakeholder Confidence (FSC), *Public information, consultation and involvement in radioactive waste management. An International Overview of Approaches and Experiences*, NEA report NEA/RWM/FSC(2003)4, OECD, Paris, March 2003, 1-81.
  - [89] Community Waste Management In Practice (CIP), European-level Guidelines for the Inclusive Governance of Radioactive Waste Management, Luxembourg, April 2010, 1-31.
  - [90] Blue Ribbon Commission on America's Nuclear Future, *Report to the Secretary of Energy*, January 2012, 1-158.
  - [91] Elam, M, G Sundqvist, *CARL Country report. Sweden*, Göteborg University, February 2006, 1-70.
  - [92] Kojo, M, *CARL Country report. Finland*, University of Tampere, May 2006, 1-96.
  - [93] Nuclear Energy Agency (NEA), *International Experiences in Safety Cases for Geological Repositories (INTESC). Outcomes of the INTESC project*, NEA report NEA No. 6251, OECD, 2009, 1-205.
  - [94] Habermas, J: *The Theory of Communicative Action*, (translated), Beacon Press, 1984.
  - [95] Zijderveld, AC, *The Waning of the Welfare State: The End of Comprehensive State Succor*. New Brunswick, Transaction Publishers, 1999.

- 
- [96] Netwerk opberging radioactief afval (NORA), *website of the NORA platform*, <https://nora.nrg.eu>
  - [97] Cuppen, E, *Putting Perspectives into Participation: Constructive Conflict Methodology for problem structuring in stakeholder dialogues*, PhD dissertation, 2010.
  - [98] Martell, M, G Ferraro, *Radioactive Waste Management Stakeholders Map in the European Union*, European Commission, Joint Research Centre - Institute for Energy and Transport Scientific and Technical Research series EUR 26692 EN/ISBN 978-92-79-38648-0, Publications Office of the European Union, Luxembourg, 2014, 1-78.
  - [99] Addams, H, J Proops (eds.), *Social discourse and environmental policy: an application of Q methodology*, Northampton, MA: Edward Elgar, 2001.
  - [100] Cotton, M, *Industry and stakeholder perspectives on the social and ethical aspects of radioactive waste management options*, Journal of Transdisciplinary Environmental Studies 11(1), 2012, 8-26.
  - [101] Verhoef E, Neeft E, Grupa J, Poley A, *Outline of a disposal concept in clay*, OPERA-PG-COV008, 2011, 1-17.
  - [102] Becker D-A, Cormenzana JL, Delos A, Duro L, Grupa J, Hart J, Landa J, Marivoet J, Orzechowski J, Schröder TJ, Vokal A, Weber J, Weetjens E, Wolf J, *Safety Indicators and Performance Indicators, Performance Assessment Methodologies in Application to Guide the Development of the Safety Case (PAMINA)*, EC, Deliverable D3.4.2, 2009, 1-75.
  - [103] Rosca-Bocancea E, TJ Schröder, *Development of Safety and Performance Indicators*, OPERA Milestone report OPERA-CF-NRG010, NRG, October 2013, 1-32.
  - [104] Schröder T J, Rosca-Bocancea E, *Safety and performance indicator calculation methodology*, OPERA-PU-NRG7312, 1-29.
  - [105] Bailey L, F Bernier, W Bollingerfehr, M Cunado, G Kwong, U Noseck, K Röhlig, A van Luik, J Weber, E Weetjens, *Safety Case Communication. Interim report of the IGSC communication group*, Internal draft document, September 2015, 1-79.
  - [106] Brunsting, S, M de Best-Waldhofer, AS Brouwer, H Riesch, D Reiner (2013). *Communicating CCS: Effects of text-only and text-and-visual depictions of CO<sub>2</sub> storage on risk perceptions and attitudes*. Energy Procedia, 37, 7318 - 7326.
  - [107] Brunsting, S, M de Best-Waldhofer, BW Terwel (2013). *'I reject your reality and substitute my own!' Why more knowledge about CO<sub>2</sub> storage hardly improves public attitudes*. Energy Procedia 37, p.7419-7427.
  - [108] Blankesteyn, M, G Munnichs, L van Drooge. *Wetenschap als strijdtoneel. Publieke controversen rond wetenschap en beleid*. Rathenau Instituut, 2014.
  - [109] Brunsting, S, M de Best-Waldhofer, CFJ Feenstra, T Mikunda. *Stakeholder Participation and Onshore CCS: Lessons from the Dutch CCS Case Barendrecht*. (2011). Energy Procedia, 4, 6376-6383.
  - [110] Brunsting, S, M Pol, J Mastop, M Kaiser, R Zimmer, S Shackley, L Mabon, R Howell, F Hepplewhite, R Loveridge, M Mazurowski, C Rybicki. *Social Site Characterisation for CO<sub>2</sub> storage operations to inform public engagement in Poland and Scotland*. Energy Procedia 37 ( 2013 ) 7327 - 7336.
  - [111] Nuclear Energy Agency (NEA), *Moving Forward with Geological Disposal of Radioactive Waste. A Collective Statement by the NEA Radioactive Waste Management Committee (RWMC)*, NEA report 6433, OECD, Paris, 2008, 1-21.
  - [112] Nuclear Energy Agency (NEA), Forum on Stakeholder Confidence (FSC), *Tools to Help Society in Decision-Making: Legal and Policy Trends. Proceedings of a Topical Session, Issy-les-Moulineaux, France, 5 June 2008*, NEA report NEA/RWM/FSC(2008)4, NEA, Paris, 2009, 1-57.
  - [113] Arnstein, SR, *A Ladder of Citizen Participation*, JAIP, Vol. 35, No. 4, (1969), pp. 216-224.

- 
- [114] Gerrits L, J Edelenbos, *Management of sediments through stakeholder involvement*, Journal of Soils and Sediments, 4, 2004; pp. 239–246.
  - [115] Janis, IL, *Groupthink: Psychological Studies of Policy Decisions and Fiascoes, Second Edition*, New York: Houghton Mifflin, 1982.
  - [116] Hart, J, 2014, *Report on the determination of the inventory*, OPERA Milestone report OPERA-PU-NRG1112A, 1-58.
  - [117] Meeussen, JCL, Rosca-Bocancea, E, 2014, *Determination of the inventory: part B matrix composition*, OPERA Interim report OPERA-IR-NRG1112B, 1-23.
  - [118] Brugge, JVM, BJ Vrouwe, *Rapportage van onderzoek aan eigenschappen van de Klei van Boom die relevant zijn bij de beschouwing van dit laagpakket voor opslag van kernafval*, T&A Survey BV, Report 1010-OEM2274, Amsterdam, 22 December 2010, 1-31.
  - [119] Vis, GJ, JM Verweij, *Geological and geohydrological characterisation of the Boom Clay and its overburden*, OPERA report OPERA-PU-TNO411, March 2014, 1-86.
  - [120] Schröder, TJ, E Rosca-Bocancea, *Wireless Data Transmission Demonstrator: from the HADES to the surface*, MoDeRn Deliverable D-3.4.2, 2013, 1-60.
  - [121] Nuclear Energy Agency/Radioactive Waste Management Committee (NEA/RWMC), *Local communities' expectations and demands on monitoring and the preservation of records, knowledge and memory of a deep geological disposal*, NEA report NEA/RWM/R(2013)4/PROV, OECD/NEA, Paris, October 2013, 1-66.
  - [122] Bundesamt für Strahlenschutz (BfS), [www.asse.bund.de/DE/1\\_Home/home\\_node.html](http://www.asse.bund.de/DE/1_Home/home_node.html), BfS, 2009-2015.
  - [123] Autoriteit Nucleaire Veiligheid en Stralingsbescherming (ANVS), *Ontwerp nationale programma radioactief afval ter inzage*, September 2015, <http://www.autoriteitnvs.nl/actueel/nieuws/2015/9/29/ontwerp-nationale-programma-radioactief-afval-ligt-ter-inzage>
  - [124] European Commission (EC), *Eurobarometer. Attitudes towards radioactive waste*, Special Eurobarometer 297, TNS Opinion & Social, June 2008, 1-140.
  - [125] Scholten LC, *Inventarisatie en mogelijkheden voor bovengrondse opslag voor 300 jaar van radioactief afval bij COVRA*, CORA report 01, KEMA Nucleair, Arnhem, 1998
  - [126] Ehrmann, JR, Stinson, BL, *Joint fact-finding and the use of technical expertise*, In: Susskind, L, McKearnan, S, Thomas Larmer, J (Eds.), *The Consensus Building Handbook*. 1999, Sage Publications, London, pp. 375-399.
  - [127] Verhoef, E, *OPERA Status*, oral presentation on the OPERA Expert Meeting No 1, November 2015.
  - [128] Hart, J, J Prij, TJ Schröder, G-J Vis, D-A Becker, J Wolf, U Noseck, D Buhmann, *Evaluation of current knowledge for building the Safety Case for salt based repositories*, OPERA report OPERA-PU-NRG221B, Augustus 2015, 1-133.
  - [129] *Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP), Deployment Plan 2011-2016*, June 2012, ISBN 978-91-979786-1-3, 1-65.
  - [130] International Atomic Energy Agency (IAEA), *Knowledge Management for Nuclear Industry Operating Organizations*, IAEA-TECDOC-1510, IAEA, Vienna, 2006, 1-176.
  - [131] Rip, A, WA Smit, BJR van der Meulen, *Radioactive Waste Disposal: Taking Societal Views Into Account*, In: Nuclear Energy Agency (NEA), *Environmental and ethical aspects of long-lived radioactive waste disposal. Proceedings of an International Workshop*, Paris, 1-2 September 1994, NEA/OECD, Paris, 1995, p.184-201.
  - [132] [www.modern-fp7.eu](http://www.modern-fp7.eu), project website of the European FP7 project MoDeRn.
  - [133] [www.modern2020.eu](http://www.modern2020.eu), project website of the European Horizon2020 project Modern2020, to be activated.
  - [134] *Kommission Lagerung hoch radioaktiver Abfallstoffe, Rückholung/Rückholbarkeit hoch radioaktiver Abfälle aus einem Endlager, Diskussionspapier vom 2. September*



- 
- 2011 der Entsorgungskommission (ESK), Ausschuss Endlagerung radioaktiver Abfälle (EL), 5. May 2015, 1-45.
- [135] [www.entria.de](http://www.entria.de), project website of the project “*Entsorgungsoptionen für radioaktive Reststoffe: Interdisziplinäre Analysen und Entwicklung von Bewertungsgrundlagen*” (ENTRIA)
- [136] Niedersächsische Technische Hochschule (NTH), *Entsorgungsoptionen für radioaktive Reststoffe: Interdisziplinäre Analysen und Entwicklung von Bewertungsgrundlagen. Vorhabenbeschreibung zur Bildung einer Forschungsplattform*, September 2013, 1-116.
- [137] European Commission. Directorate-General for Research & Innovation, Grant agreement number 662177 – Modern2020. ANNEX 1 (part A) Research and Innovation action, Ref. Ares(2015)1992647, May 2015, 1-116.







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