The draft national programme for the management of spent fuel and radioactive waste

(ANVS-2016/237)

Contents

Summary

The national programme describes the policy for the management of radioactive waste and spent fuel, from origin through to disposal. Radioactive waste and spent fuel are stored aboveground for a period of at least 100 years. Geological disposal is envisaged in around 2130. The choice of location is not yet the subject of discussion.

In our modern society, it is possible for anyone to be affected by an activity in which radioactivity is used or produced. For example, in the use of medical isotopes in health care, in power generation and in laboratories, radioactive waste is an unavoidable consequence. In the past, radioactive waste was also produced in the Netherlands. This waste is currently safely stored in specially designed buildings at the Central Organisation For Radioactive Waste (COVRA) in Zeeland. Now and in the future, the management of radioactive waste and spent fuel, also viewed as radioactive waste, (hereinafter: radioactive waste) must be such that it represents no danger to man or the environment. This national programme does not discuss the position of nuclear energy in the energy mix; instead it describes the management of radioactive waste already present and to be produced in the future.

Volume of radioactive waste
At present, almost 86 m^3 of high level radioactive waste is stored at COVRA. In terms of size, this equates to approximately the capacity of a large sea container. Approximately 70% of this waste resulted from the production of nuclear power. Of the remaining 30%, most has arisen from the production and use of medical isotopes, and a small proportion from research.
Approximately 11,000 m^3 of low level and intermediate level radioactive waste are also stored at COVRA. This waste originates mainly from industrial applications, but also from laboratories, hospitals and the production of nuclear power. A further approximately 17,000 m^3 of NORM waste: radioactive waste from natural materials such as ores, are stored at COVRA. At the start of 2015, in total almost 30,000 m^3 of radioactive waste was stored at COVRA. In 2130, forecasts suggest that 70,000 m^3 of radioactive waste will be in storage, of which 401 m^3 will be high level radioactive waste.

In the past (1985-1992), radioactive waste was stored at the ECN site in Petten. A project is currently being implemented to transfer this so-called 'historical waste' to COVRA.

Policy on radioactive waste
The Dutch policy on radioactive waste is based on four principles:

- Minimisation of the production of radioactive waste
- Safe management of radioactive waste
- No unreasonable burdens on the shoulders of future generations
- The causers of the radioactive waste are responsible for the costs of its management.

The policy is stable and for more than thirty years has assumed the aboveground storage of the radioactive waste for a period of at least 100 years, after which disposal deep belowground is envisaged in around 2130. The definitive decision on this disposal method will be taken around 2100. At that time, society may opt for a different management option, depending on the state of understanding at that time, and assuming that other alternatives are available by that time. The relatively long period of aboveground storage will provide time to learn from experiences in other countries, to carry out research and to accumulate knowledge. In this way, sufficient money can also be set aside to make eventual disposal possible. As a consequence, in the future, a well-argued decision on the

management of radioactive waste can be taken, without unreasonable burdens being placed on future generations.

New policy
As well as a description of current policy for the management of radioactive waste and spent fuel, the national programme represents an updated version of that policy. In that sense, it serves as the starting point for the decision-making process in respect of eventual disposal.

As well as considering the current approach to the management of radioactive waste, visions on possible management in the future are given. New elements in this programme are flexibility and the dual strategy in achieving disposal. Also new is the process of monitoring developments concerning disposal, in the form of trend analyses and assessments and the issuing of advice on those issues. These aspects will be discussed in more detail below.

Long-term management
This national programme is based on current thinking on the management of radioactive waste. High level radioactive waste must be safely managed for many thousands or even up to a quarter of a million years, until the radiation level has fallen to the point where it is no longer hazardous. The length of this period is determined by whether or not the waste has been reprocessed. For low level and intermediate level radioactive waste, this period is between hundreds and thousands of years. Deep burying is currently viewed, both nationally and internationally, as the safest and most reliable means of managing high level radioactive waste in the long term. At present, it is the only solution that guarantees that radioactive waste remains beyond the sphere of influence of man, even after many thousands of years. The initial study into options for the management of radioactive waste, which was prepared to underpin this programme, and the current state of knowledge and technology, both nationally and internationally, all point in this direction. Given the relatively small volumes of radioactive waste and the high costs for geological disposal, low level and intermediate level radioactive waste will be stored in the same location as the high level radioactive waste. In this national programme, the roadmap towards geological disposal is further elaborated.

A number of countries including Finland, France and Sweden are already taking steps towards geological disposal of high level radioactive waste and spent fuel. According to expectations, the first geological disposal sites for high level radioactive waste will become operational in Europe, around 2025. There are however other countries that are following the Dutch policy of long-term aboveground storage (Spain) or are investigating the possibilities of this approach (Germany, United States). For a country like the Netherlands, with a limited volume of radioactive waste, a relatively small nuclear sector and a limited research budget, it does not seem logical to want to be a frontrunner in establishing a disposal site, but instead to learn from and share the experiences acquired internationally.

Flexibility in the future
It is not possible to predict with any certainty what the best means of managing radioactive waste will be when it becomes time to reach a decision in 2100, or what then social thinking will be. Before that time, developments may take place that justify another choice than geological disposal of the radioactive waste on Dutch territory. Possibilities include technological developments or international cooperation in achieving a disposal option for radioactive waste.

Because of the uncertainties outlined above, it is essential to be able to respond flexibly in the future in terms of timetable and management options. At present, geological disposal appears to be the most obvious option, but at the same time, it is important to not now cast the route towards geological disposal in stone, in the form of decision making. It is for example not yet necessary to select a location for disposal, which is not expected to actually be implemented during the course of the coming century. Insights into a favourable location could after all change over the coming decades. On the other hand, financial provisions are already being made. There must also be no possible uncertainty about the responsibility regarding the management of radioactive waste.

To achieve actual disposal, both a national and an international line are being followed: a so-called dual strategy. Within this strategy, a national route towards disposal will be elaborated while at the same time the possibility of collaborating with other European Member States in establishing a disposal location will not be excluded. If this possibility arises, it must still be possible to respond appropriately.

Challenge for future generations
Because of its long life, radioactive waste represents a challenge for several generations. The current generation is responsible for the safe storage of radioactive waste today, and is involved in research into disposal. A series of measures have been taken to ensure that sufficient financial resources are available for the safe management of radioactive waste.
At the end of the day, around the year 2100, future generations should be in a position to take a well-argued decision on the management of radioactive waste and spent fuel for the long term, on the basis of the then current technology and understanding. By providing these generations with the necessary – financial – resources for achieving disposal, and at the same time demonstrating a flexible approach towards disposal, they will be allowed the freedom to choose the best management route at that moment, without having imposed unreasonable demands on them.

Consultation group
By periodically preparing trend analyses relating to developments concerning the management of radioactive waste in the long term and having these trends assessed by a consultation group – to be established in 2016 – consisting of representatives of social, scientific and administrative organisations, progress will be maintained in the process towards disposal. These trend analyses should consider political-administrative, technical-scientific, international and social developments and spatial aspects. The consultation group can then advise on whether there are grounds for initiating or intensifying particular programmes, for example international cooperation, research or public participation.
The Cabinet has identified agenda items for the consultation group, for the next report to the European Commission. These points will offer the consultation group clearer direction and focus. The consultation group has been asked to focus attention on:

- identifying specific forms of participation
- financing of disposal and the related uncertainties
- potential suitable search areas for the disposal of radioactive waste that can be reserved, and identifying the necessary policy harmonisation, given other future functions of the (deep) underground environment at those sites.
- maintaining the necessary knowledge structure in the Netherlands
- the criteria for determining the period of retrievability of radioactive waste from disposal
- the possible policy implications of the results of OPERA.

The Cabinet will use the report from the consultation group on these points in reviewing the national programme in 2025.

Societal involvement essential

The management of radioactive waste for the long term is a complex subject: it affects not only our generation but also future generations. A carefully-considered decision in the future is essential for achieving disposal. At present, however, it does not appear meaningful to initiate public participation in respect of disposal: studies in support of this national programme reveal that the absence of actual decisions mean that at present there is no sense of urgency among the public, for participation in a debate.

Nonetheless, society must be involved on time in the decision-making process concerning disposal of radioactive waste. Not only the residents of the Netherlands but also governments like municipalities and provinces and social organisations are needed to participate. Local and provincial government, for example, each have their own role in respect of spatial decisions, as the stakeholder organisations in the field of the environment, sustainability and society. The waste management organisations and scientists also have a role to play. Any decision on the management of radioactive waste in the long term can only be taken if considered by society as a whole, if every stakeholder plays his or her role, and if all players are confident in one another. International experience has shown that disposal cannot be achieved if there is no support within society for the process.

This means that the public participation process must be both careful and realistic. By starting to make preparations for this decision-making process on time, society in the future will be able to take a carefully considered decision. However, at present it is difficult to set a starting point for this participation. Technological developments, international developments and for example administrative changes at national or European level mean that the timetable on the road to the year 2100 is uncertain. The closure of the nuclear power plant in Borssele could be a good moment for initiating public participation. Trend analyses should give consideration to this possibility.

Naturally, there are a number of consultation moments in the licencing process for the management of radioactive waste. During these consultation moments, everyone is given an opportunity to present his or her point of view on the licence in question. This national programme is also available for examination at those moments.

Planning and action points
This is the first national programme in accordance with Directive 2011/70/Euratom. Every ten years, the policy on the management of radioactive waste will be updated in the national programme to be submitted to the European Commission. The action points in the national programme help to measure the progress of the process. Every three years the Netherlands reports to the European Commission on the implementation of the Directive. The reporting moments will also be used, where necessary, to revise the action points. In this way, the Cabinet will work towards disposal in a phased approach.

Part A – Context

In the national programme, the Cabinet describes the policy on radioactive waste and spent fuel from its origins through to the long-term management. In chapters 1 and 2, the background and realisation of the national programme are described in outline. Chapter 3 provides and overview of the volume of radioactive waste now and in the future.

Chapter 1 – Introduction

The establishment of the European Directive for the management of radioactive waste led to the decision to update certain parts of the policy on radioactive waste. The aim of this policy is firstly to minimise the production of radioactive waste, and secondly to ensure the safe management of radioactive waste now and in the future.

1.1 Background: European Directive

In July 2011, for the first time ever, a European Directive for the management of radioactive waste was adopted: Directive 2011/70/Euratom establishing a community framework for the safe management of spent fuel and radioactive waste (hereinafter: the Directive). On the basis of this Directive, the European Member States are required to prepare a national programme for the management of their spent fuel and radioactive waste (hereinafter: the national programme).

The national programme describes the policy for the current and future management of radioactive waste and spent fuel. The programme also contains concepts and plans for a management option for the long term, alongside current research activities, financing schemes and the involvement of the public in the decision-making process concerning the management of radioactive waste.

The main thrust of waste policy as established since 1984 will be maintained: aboveground storage of radioactive waste for at least 100 years followed by geological disposal. The drawing up of the national programme is a perfect opportunity to consider whether parts of the policy need to be revised. This national programme provides a clear summary of the developments over the past few years, wherever necessary updating those developments and describes further steps in the future. This approach provides the time needed to further develop and as necessary adjust the policy on the management of radioactive waste, over the years, on the basis of international, technical and social developments.

1.2 Objective: safe and responsible management now and in the future

The objective of this first national programme is to describe how the safe and responsible management of radioactive waste and spent fuel in the Netherlands is regulated now, and in the future. The current generation has been able to profit from the advantages of the use of nuclear power and other applications of radioactivity, and is therefore required to take the necessary steps to ensure safe and responsible management now and in the future (high level radioactive waste, for example must be managed securely for many thousands of years[1] until the radiation level is no longer hazardous). To achieve this situation, policy is aimed at enabling current and future generations to make clearly considered choices on the means of managing radioactive waste and spent fuel, in the long term.

1.3 Reading this document

This national programme consists of a main text and annexes.

[1] For reprocessed radioactive waste this is approximately ten thousand years; for non-reprocessed spent fuel, the storage period is approximately a quarter of a million years.

Main text

The main text consists of three parts. Part A considers the context of this national programme and the question of how much radioactive waste there is in the Netherlands. In chapters 1 and 2, an outline is given of the background and the way in which the national programme was prepared. Chapter 3 provides an overview of the volume of radioactive waste now and in the future.

In part B, the policy on radioactive waste itself is considered. The policy is described in chapter 4. This policy will be tightened up in a number of respects. The policy principles remain in place and unaltered. Chapter 5 then deals with legislation and regulations. Part C offers a vision on the process towards disposal. How can we ensure that radioactive waste remains safely managed now and in the future? And what are the actions that emerge from that process? Chapter 6 deals with the question of how the decision-making process will be structured and how the public will be involved. Action points from the programme and milestones towards realisation of disposal and process indicators for the national programme are listed in chapter 7.

Annexes

There are seven annexes. Annex A contains a list of terms, definitions and abbreviations. Annex B discusses radiation, its applications and risks. The organisations involved in the management of radioactive waste are then described, including the competent authority (annex C) and the waste management organisation COVRA (annex D). Annex E discusses a number of aspects of disposal. Annex F refers to where the obligations from the Directive are reflected in this national programme.

Background information

All background documents on which this national programme is based are available via www.autoriteitnvs.nl/onderwerpen/radioactief-afval. This background information is not part of the national programme.

Chapter 2 – Method

The national programme is based on the Nuclear Energy Act and regulations. This chapter describes how the programme was drawn up and how it is kept up to date. The chapter also considers demarcation: the programme does not consider the discussion on whether or not to stop producing nuclear power.

2.1 Establishment: underlying studies

With the introduction of Directive 2011/70/Euratom, every Member State has been set the obligation to draw up a national programme. This national programme describes the current state of affairs in respect of Dutch policy in the field of management of radioactive waste, including disposal. The programme includes proposals for additions to the policy. These additions were previously announced to the Dutch Lower Chamber[2]. The drawing up of the national programme represents the ideal opportunity to consider whether parts of the policy needed to be updated. After all, the foundations for current policy were laid down in 1984.

In preparation of the programme, four studies were carried out:

1. Inventory of the current and future volume of radioactive waste by COVRA (hereinafter: waste inventory);
2. Initial study into options for the long-term management of radioactive waste by ARCADIS Nederland BV (hereinafter: initial study);
3. Vision and strategy on public participation by the Rathenau Institute (hereinafter: public participation report);
4. State of affairs concerning international research into disposal by the Nuclear Research & Consultancy Group (NRG) (hereinafter: international research report).

Together with (inter)national literature and reports by authoritative bodies[3], these studies were used as background information for drawing up the national programme[4]. An analysis of online debate of the discussion concerning radioactive waste and disposal was also undertaken by EMMA Communicatie (hereinafter: analysis of online debate report).

Furthermore, the NCEA was asked to issue advice[5] on the scope and level of detail of the initial study for the long-term management of radioactive waste. In consultation with NCEA, the scope of this request for advice was broadened, and focused on the entire national programme. This was in part due to the consultation reactions received during the public presentation of the project plan of this initial study. The NCEA has also assessed the draft national programme on radioactive waste according to the previous recommendations, scope and level of detail. The Cabinet considered the views of the initial study, and the draft national programme, as expressed both by the public and the NCEA, in drawing up this national programme. See annex G.

Figure 2.1 is a representation of this information.

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[2] Parliamentary papers, session year 2012-2013, 25 422, no. 105.

[3] For an overview of international organisations see annex E.2.3.

[4] The underlying studies are available at www.anvs.nl under the subject heading radioactive waste.

[5] See www.Commissionmer.nl; recommendation 2842.

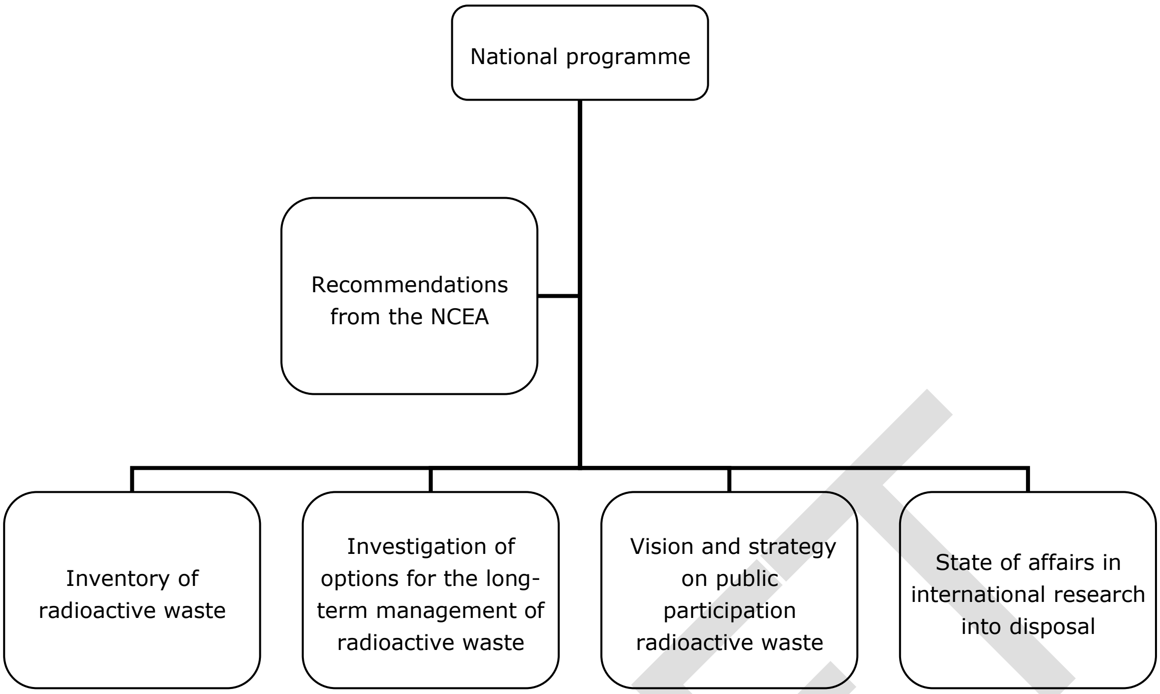

Figure 2.1 The national programme and underlying studies.

Environmental Impact Assessment

In preparing the national programme, the question arose as to whether an Environmental Impact Assessment (EIA) needed to be drawn up. Although the NCEA believed that this was necessary, no EIA report was drawn up for the national programme. On the basis of article 7.2 of the Environmental Management Act (Wm), an EIA report must be drawn up whenever a plan relates to activities subject to a compulsory EIA, and the plan forms the framework for a subsequent decision. This is however not the case for the national programme. This national programme deals primarily with the 'route' which will lead to actual disposal. The concept for disposal is still so abstract that it cannot be argued that this plan lays down frameworks for subsequent decision making. On the other hand, the concept for disposal will become increasingly specific over time, as a result of which at some point in the future, a plan will be drawn up that is subject to a compulsory Environmental Impact Assessment.

Naturally, the environmental effects of the process towards disposal will have to be fully assessed in the decision-making process. An investigation will be undertaken into the criteria applicable before a start is made on the first EIA report (see action point chapter 7.1.2).

The current method of managing radioactive waste – aboveground storage at COVRA – is earmarked as an activity subject to a compulsory EIA. At the time, when the processing and storage facilities at COVRA were established, an Environmental Impact Assessment report (EIA) was indeed prepared. At the end of 2013, COVRA also drew up an EIA report in preparation of the licence application for expansion of the storage capacity for heat-producing high level radioactive waste and optimisation of the equipment of the facility for low level and intermediate level radioactive waste.

In the framework of the national programme, an initial study has been carried out into the options for the long-term management of radioactive waste and spent fuel (see initial study). Within this study, an overview is given of the options for the long-term management of radioactive waste which may be suitable for the Netherlands, together with a description of the advantages and disadvantages of these management options, in respect of four aspects (safety, geology, economics and ethics). The initial study, just like this national programme, was made available for public consultation.

2.2 Updating: a new national programme every ten years

The Minister of Infrastructure and the Environment updates the national programme at least every ten years. This matches the period laid down in the Directive for the evaluation of the national framework for the management of radioactive waste and spent fuel. This means that this national programme will have to be updated at the latest by 2025. The current national programme discusses the social, technical and scientific developments in the field of radioactive waste. Relevant results and developments in other European Member States are also considered (see action point chapter 7.1.2).

In addition to this ten-yearly updating cycle, the Member State is required to issue a report in a three-year cycle on the progress in implementing the national programme, to the European Commission. The Minister of Infrastructure and the Environment will be submitting the first report on these developments at the same time that the national programme is sent to the European Commission (see action point chapter 7.1.2).

2.3 Demarcation: no discussion about nuclear power

This national programme deals with the management of radioactive waste: now and in the future. The national programme does not consider issues relating to the justification of the use of radioactive substances and fission materials. This latter category of questions falls within the framework of the *Regulation on the announcement of justification of the use of ionising radiation*. The national programme is also not able to exclude possible applications in advance, thereby avoiding the production of radioactive waste. The principle of minimisation does however apply to these activities (see chapter 4).

In other words, the national programme does not deal with the discussion on whether or not to halt the production of nuclear power. That discussion will be held within the framework of determining the energy mix. Nonetheless, nuclear power and radioactive waste cannot be viewed separately within the social debate. The national programme refers to more than 'nuclear waste'. Some social organisations view the phasing out of nuclear power as an essential requirement for decision making on the disposal of radioactive waste. Although the production of nuclear power is a major source of high level radioactive waste (approx. 70%) it is not the sole source. High level radioactive waste is also produced as a by-product of medical isotopes (30%) (see chapter 3).

The national programme relates to all fission materials and radioactive waste substances to which the *Nuclear Energy Act* applies, and for which no reuse is planned. This includes:

- spent fuel (as intended in the *Nuclear Installations, Fissionable Materials and Ores Decree);*
- radioactive waste substances (as intended in the *Radiation Protection Decree*).

This under all circumstances includes:

- radioactive waste produced in the Netherlands as a consequence of licenced actions and activities involving radioactivity;
- spent fuel used in the Netherlands;
- radioactive reprocessing waste, including reprocessing waste still to be returned from abroad;
- orphan sources;
- radioactive waste from the dismantling of Dutch nuclear reactors, cyclotrons and particle accelerators;

- radioactive waste from possible future remediation of sites with radioactive contamination or of companies using natural radioactive materials (NORM).

The national programme does not relate to:

- radioactive waste materials (possibly) originating abroad;
- depleted uranium and other residue from the enrichment of natural uranium, unless identified as radioactive waste;
- NORM waste subject to compulsory reporting that is dumped or reused at designated landfills as very low level radioactive waste (ZELA).
- This national programme is not considered as including the Netherlands Caribbean territories. Nuclear Power legislation and the Euratom Treaty do not apply in those territories.

2.4 OPERA: the Dutch research programme

The five-year Research Programme for the Geological Disposal of Radioactive Waste (OPERA, 2011-2016) is currently underway. This programme aims to investigate how safe long-term disposal of radioactive waste can be achieved in the Netherlands. With this in mind, within OPERA, Safety Cases[6] will be developed for the disposal of radioactive waste in rock salt and Boom Clay, both of which are host rocks occurring in the Netherlands. Alongside long-term safety, the technical feasibility of the disposal concept in Boom Clay will be further examined, within OPERA. Current cost estimates for disposal in both host rocks will also be developed. Research into other potentially suitable clay layers (such as Ypresian Clay) may be discussed in passing. A second objective of OPERA is to contribute to the establishment of the knowledge infrastructure in respect of disposal. Within OPERA, attempts will be made to link up and cooperate with the Belgian research programme into the disposal of radioactive waste.

The radioactive waste management organisation COVRA is responsible for coordinating the OPERA research programme. The owner of the Borssele nuclear power plant (N.V. Elektriciteits-Produktiemaatschappij Zuid-Nederland, EPZ) and the Dutch Government will act as financiers, each responsible for covering half of the ten million euro programme. Various scientific organisations will be participating in one or more subprojects.

Implementation of this research programme has both a substantive and a management aspect. A distinction has been made between the two. For the substantive aspect, an Advisory Group has been established while technical supervision of the research programme and management of the funds will be undertaken by COVRA. The Steering Committee (with representatives from the ANVS and the nuclear sector) will monitor the overall process. The Advisory Group (consisting of members with administrative, social-societal or relevant academic backgrounds) will focus on the substantive evaluation of the research to be implemented, and will advise COVRA[7].

The majority of the research results at OPERA are expected around the end of 2016. The planning cycles between the national programme and OPERA are not synchronous, so that the results from OPERA will not yet be available during the period in which this national programme is drawn up. OPERA had already been started before the European Directive was introduced, requiring the adoption of a national programme. Wherever possible, use will be made in this programme of the results from OPERA that are already available. Following completion of OPERA, the consultation group will focus attention on possible policy implications (see action point chapter 7.1.2).

[6] Definition Safety Case: an integration of scientific and technological arguments and supporting arguments that describes the safety and feasibility and where possible quantifies the safety, feasibility and level of reliability of the proposed management solution. [from: OPERA Multiyear Plan.]

[7] OPERA implementation plan.

Partition and transmutation

In a European context, research is being undertaken into partition and transmutation (P&T), a technique still in the experimental stage whereby the life of radioactive waste can be shortened. On a laboratory scale, life reduction has been proven possible for certain atoms from radioactive waste, the actinides[8] but P&T cannot yet be applied on a large scale. P&T requires a breeder reactor, a special type of nuclear reactor at present only available in the few countries in the world. During the process, high level radioactive waste is produced that must be kept in a disposal location. In other words, although P&T is a technology that can shorten the life of radioactive waste, a disposal option is still always needed, for the resultant high level radioactive waste.

The reprocessed and vitrified high level radioactive waste from the Borssele nuclear power plant is no longer suitable for further processing. As a result, P&T is no longer possible in respect of all existing high level radioactive waste.

[8] Atoms with atomic numbers 90 through to 103.

Chapter 3 – Radioactive waste

This chapter discusses the origin of radioactive waste. An overview is also provided of the volumes now and in the future.

3.1 What is radioactive waste?

A radioactive substance can be designated as radioactive waste by the Minister of Infrastructure and the Environment, or the commercial operator, if no product or material reuse is planned for the material by either the Minister or by the commercial operator, and there is no question of dumping the material[9].

Radioactive waste substances must be safely managed up to the moment that they are no longer radioactive (the remaining radioactivity is below the release thresholds). In the Netherlands, spent fuel is described as the fission material that is irradiated and permanently removed from the reactor core[10]. This spent fuel can be viewed as a usable source, that can be reprocessed, or as radioactive waste that is intended for disposal. The choice is left to the licence holder of the reactor. If the spent fuel is viewed as waste, the management of that waste is subject to the policy for the management of radioactive waste.

If the activity level of the radioactive waste falls below a certain threshold or is brought below that threshold as a result of decay, it is by definition no longer radioactive waste. It can then be safely released for reuse or discharged to a conventional waste processor. The release thresholds are laid down in law in the *Implementation Regulations for Radiation Protection Economic Affairs*, and differ for each radionuclide.

Radioactive waste is diverse in its composition: its life may be very short or very long. Sometimes a great deal of heat is also released or the waste is toxic. The specific properties of the radioactive waste have consequences for the management method. Depending on the precise composition of the radioactive waste, it must be safely stored for days, years, hundreds or years or even hundreds of thousands of years.

Two properties of radioactive materials are relevant for the method of classification of radioactive waste: activity and half-life.

Activity

The activity of a radioactive substance is defined as the number of spontaneous nuclear mutations per time unit. The type and energy of the radiation released as a result of the mutation will determine how hazardous a radioactive source or material is. The amount of activity radiated per second by a radioactive source is expressed in the unit Becquerel (Bq).

Half-life

The half-life ($t_{1/2}$) is the time within which half of all radioactive atoms in a material decay into stable atoms. As a result of radioactive decay, the activity of a radioactive source is continuously decreasing (see figure 3.1). The half-life of different radionuclides can vary enormously; from for example 0.16 seconds for polonium-216 to 24,100 years for plutonium-239.

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[9] Definition of radioactive waste according to *Radiation Protection Decree.*

[10] Definition of spent fuel according to the *Nuclear Installations, Fissionable Material and Ores Decree.*

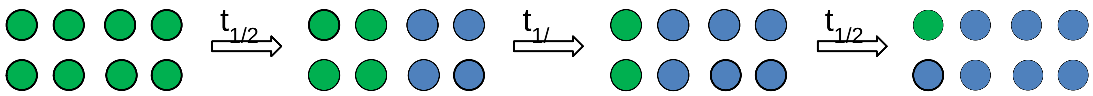

Figure 3.1 Radioactive decay: after three half-lives, one eighth of the original volume of radioactivity remains.

3.2 Origin

Radioactive waste can be produced following the use of raw materials or radioactive substances. These materials may be spent fuels, but also radioactive sources or materials contaminated with radioactivity such as laboratory gloves and coats or radioactive boiler scale (removed from pipes at refineries). In addition to industrial sectors where radioactivity is a by-product of the process (for example oil and gas production), the Netherlands also has industrial and medical sectors that make deliberate use of the applications of radioactive materials, in various ways. There are approximately 1300 licence holders according to the *Nuclear Energy Act*; approximately two thirds of them currently produce or in the future will produce waste that is more or less radioactive. The waste producers can be divided into six sectors: nuclear, industry, medical, NORM industry, research and miscellaneous.

The nuclear facilities in the Netherlands that produce radioactive waste are:

- the EPZ nuclear power reactor in Borssele (485 MWe);
- the research reactors in Petten and Delft:
    - High Flux Reactor (HFR, 45 MWth) at NRG in Petten. The HFR produces approximately 30% of all medical isotopes in the world. These isotopes are used to treat 24,000 patients every day;
    - Higher Education Reactor (HOR, 3 MWth) at Delft University of Technology. The HOR is used for research and teaching purposes;
- the uranium enrichment plant URENCO in Almelo (6200 tSW/year).

There are also two decommissioned nuclear installations; the nuclear power reactor (GKN, 60 MWe) in Dodewaard and the Low Flux Reactor (LFR, 30 kWth) at NRG in Petten. No further radioactive waste is produced in these installations, but radioactive waste will be produced when they are dismantled. Figure 3.2 shows where the nuclear installations in the Netherlands are located.

Figure 3.2 The nuclear installations in the Netherlands.

3.3 Types of radioactive waste

There are no internationally agreed waste classifications. The IAEA (International Atomic Energy Agency) has however developed a classification for charting out the worldwide volume of radioactive waste. Roughly speaking, the IAEA categories *high level waste* and *intermediate level waste* equate broadly with the Dutch category 'hoog radioactief afval' and the IAEA categories *low level waste* and *very low level waste* met the Nederlandse category 'laag- en middelradioactief afval' (see figure 3.3).

In the Netherlands, radioactive waste is divided into four categories: high level radioactive waste, low level and intermediate level radioactive waste (including NORM waste), short-lived waste and exempt waste. These categories are based on activity and half-life.

1. High level radioactive waste (HRA)

The majority of HRA consists of waste originating from the generation of spent fuel rods from the nuclear power reactors at Borssele and Dodewaard (approx. 70%). The remainder consists of the fission elements from research reactors in Petten and Delft, and waste from the production of medical isotopes (30%). A proportion of the HRA (39%) produces heat and must be cooled. The heat production by HRA will diminish rapidly in the one hundred-year period of aboveground storage due to radioactive decay. The HRA contains radionuclides with very long half-lives of sometimes tens of thousands of years. As a result, HRA must be safely stored for a very long period. During the dismantling of nuclear installations and the remediation of historical waste (see 3.4.1 and action point in chapter 7.7.1), HRA may be produced. In the reprocessing of fission materials, non-heat-producing high level radioactive waste is also produced, which is also stored at COVRA.

2. Low level and intermediate level radioactive waste (LMRA) and NORM waste

LMRA waste has a lower activity than HRA waste. LMRA is produced in a wide range of activities and consists among other items of articles from laboratories, smoke alarms and replaced parts such as pipes, pumps and filters. LMRA consists of both long-lived and short-lived waste. A distinction is made between four types of LMRA: alpha-bearing waste, waste from a nuclear power plant, waste with a half-life of longer than 15 years and waste with a half-life of shorter than 15 years. Approximately two thirds of the LMRA waste will decay so far over the next 100 years that it can subsequently be processed as conventional waste.

NORM waste

A special category of LMRA waste consists of NORM waste (Naturally Occurring Radioactive Material, i.e. waste produced from the use of natural raw materials). NORM waste is for example produced when naturally radioactive substances that occur in industrial ores (such as phosphate ores) are concentrated in waste as the result of an industrial process such as for example in the gas and oil industry and the ore-processing industry. This waste must be managed as LMRA waste.

Under certain conditions, and if there is no increased risk for man and the environment (Bs, article 110a), NORM material may be mixed with other materials for reuse. However, mixing is forbidden if its sole purpose is to reduce the activity concentration (the amount of radioactivity per gram of material) (Bs, article 38). Waste with an activity concentration that is more than 10 times higher than the exemption threshold must be entrusted to COVRA.

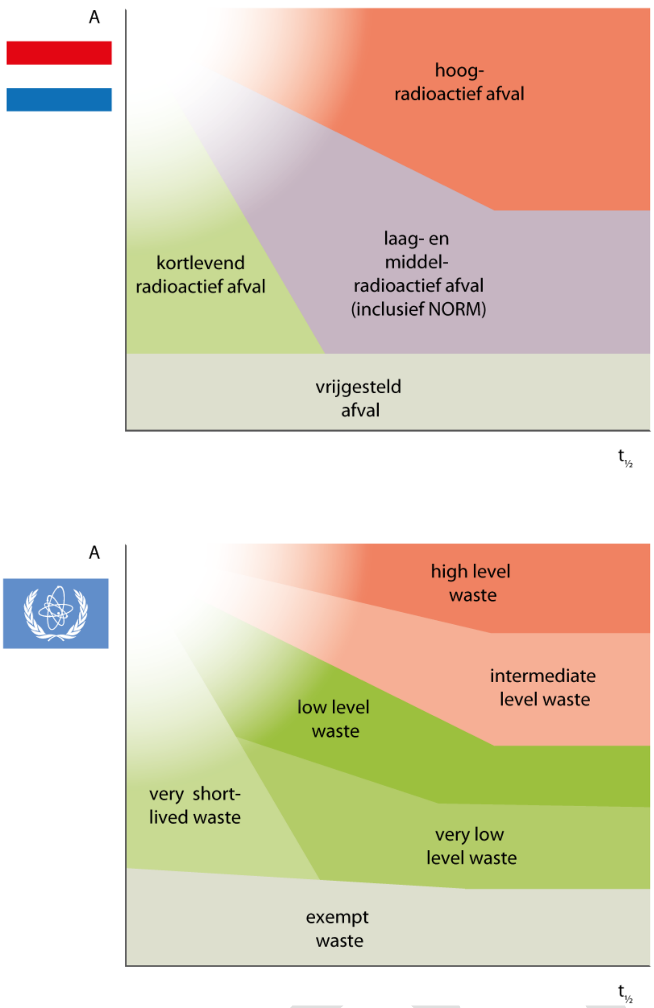

Figure 3.3 The IAEA and Dutch classification for radioactive waste.

NORM waste with an activity concentration of up to 10 times higher than the exemption threshold need not be entrusted to COVRA, but can be safely dumped as very low level waste (ZELA) at special licenced dumpsites. Although ZELA is beyond the scope of this national programme, for the sake of completeness, it is considered in the following section.

3. Short-lived waste

Radioactive waste with a half-life of less than 100 days may be stored with the producer for a maximum of 2 years in a suitable facility, subject to inspection. If after this period, the waste has decayed to below the release threshold, it can be managed as conventional waste. Because of this short period of time, this waste is not included in the waste inventory.

4. Exempt waste

Exempt waste is waste that is below the exemption thresholds[11]. This waste has such low radioactivity levels that it can safely be disposed of or processed as conventional waste. This waste is not included in the waste inventory.

[11] When drawing up the waste inventory and this national programme, the release and exemption thresholds applicable in 2015 were used.

3.4 Volumes

3.4.1 Current volume of radioactive waste

The volume of radioactive waste, now and in the future, forms the basis for the national programme. With that in mind, assuming the current release and exemption thresholds, an inventory has been prepared of the current volume of radioactive waste, together with an estimate of the future production (see waste inventory). Radioactive waste must be transported to COVRA for storage (see annex D for the management of radioactive waste at COVRA).

In the new European basic standard (BSS, Directive 2013/59/Euratom), the release and exemption thresholds have been updated. One action point included in this national programme is to investigate the consequences of the implementation of the BSS on the volume of radioactive waste (see action point chapter 7.1.1).

At present, 86 m^3 of HRA are stored at COVRA, together with 11,000 m^3 of LMRA and 17,000 m^3 of NORM waste. HRA represents just 0.3% of the total volume but still represents the largest proportion of total activity. Figure 3.4 shows the volumes and activity levels in diagrammatic form:

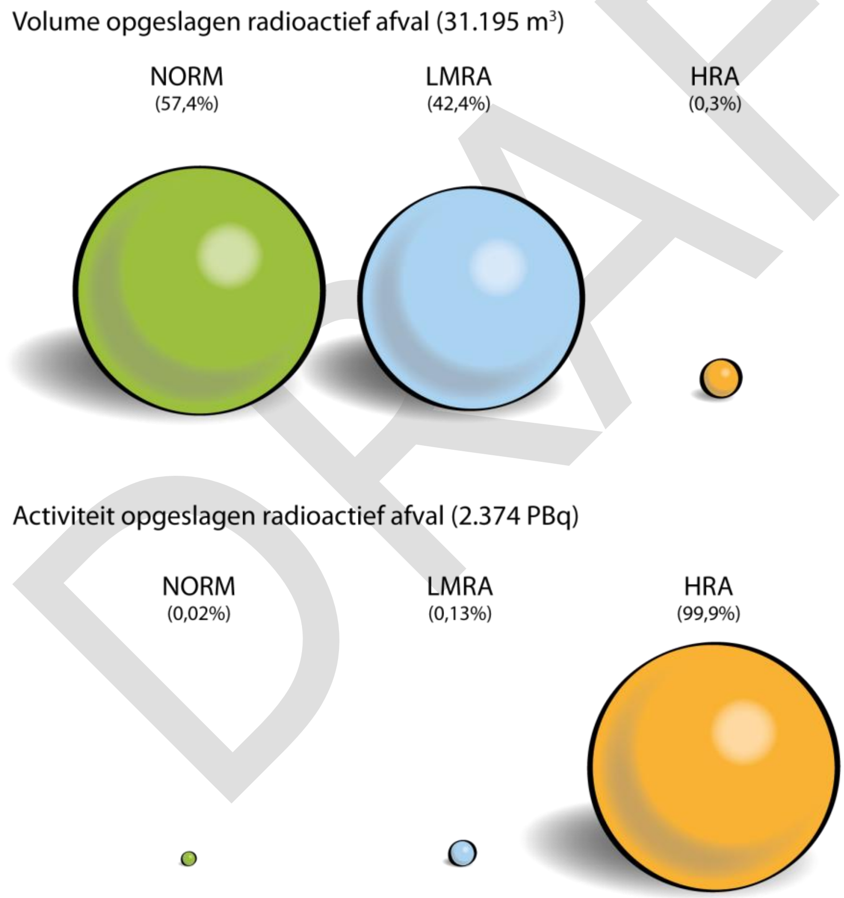

Figure 3.4 Activity and volume of radioactive waste at COVRA.

A minute fraction of the HRA and approximately 20% of the LMRA remains stored with its producer. This radioactive waste must be reused or transported to COVRA. Part of this waste is stored in Petten and dates back to before the establishment of COVRA. A project is currently underway for transferring this so-called historical waste to COVRA (see action point chapter 7.1.1).

3.4.2 Production and processing

Each year, more than 38,000 m^3 of radioactive waste are produced in the Netherlands. The vast majority is NORM waste (37,000 m^3 per year). In volume, NORM waste represents almost 99% of the radioactive waste produced in the Netherlands. A small proportion of this waste is transported to COVRA as radioactive waste (approximately 1280 m^3). The majority of this NORM waste is dumped at special sites as ZELA. Although ZELA is beyond the scope of the national programme, for the sake of completeness, it is included in this section. In addition, each year, 6.3 m^3 of HRA and 504 m^3 of LMRA are delivered to COVRA. Figure 3.5 shows the annual production and processing of radioactive waste in diagrammatic form.

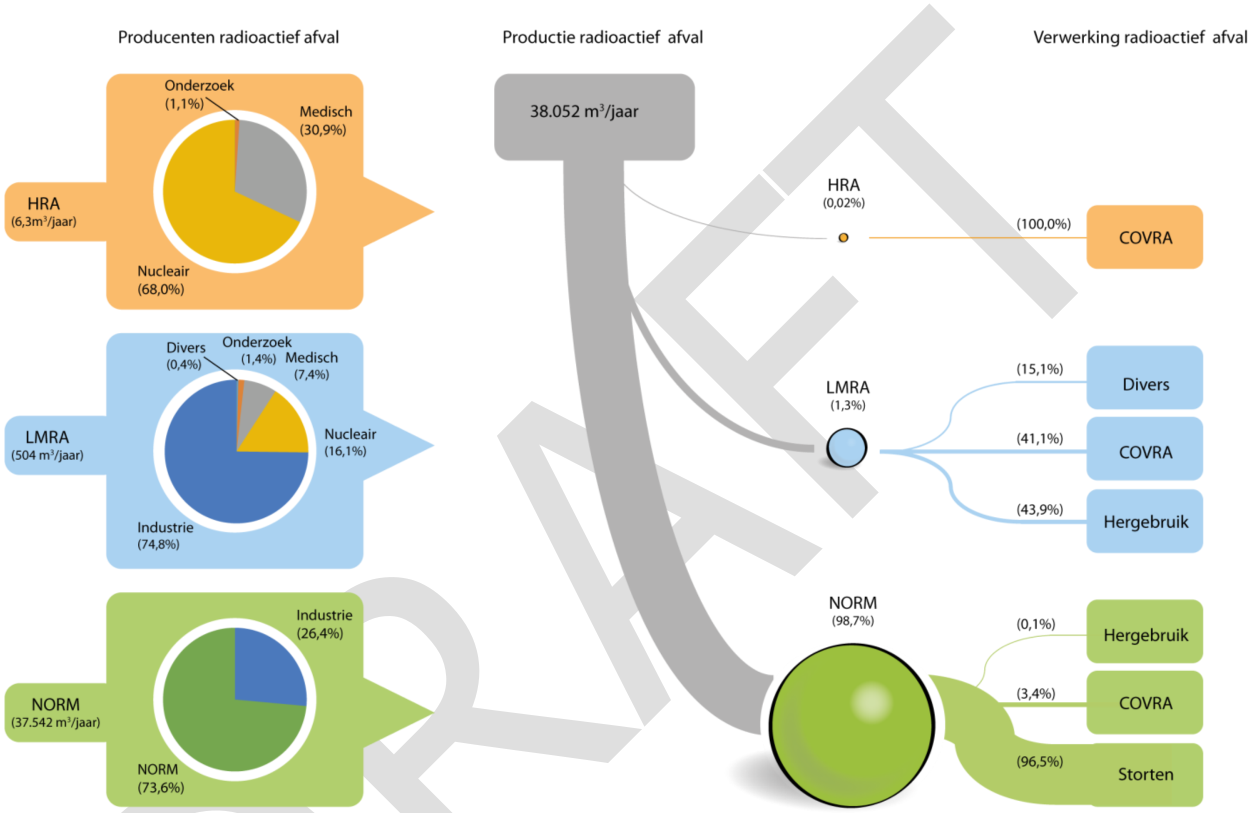

Figure 3.5. Producers, annual production and processing of radioactive waste (including ZELA) in 2013.

3.4.3 Future volume of radioactive waste

On the basis of interviews with waste producers, data from dismantling plans and extrapolation of the current volumes of waste supplied, an estimate has been made of the expected volumes of radioactive waste in the future. The estimates are based on the current release and exemption thresholds. Changes to this policy could have major consequences for the volume of radioactive waste. The annual volume of LMRA for example fell by 40% following the raising of the statutory release and exemption thresholds in 2001. A second nuclear power station would of course also change the picture. Over the next few paragraphs, an estimate is made of the growth of HRA, LMRA and NORM through to 2130.

Every three years, in the report to the European Commission, a new waste inventory with an estimate of future volumes of radioactive waste will be drawn up (see action point chapter 7.1.2).

HRA

The volume of HRA in 2130 is estimated at 400 m^3 (see figure 3.6). Of that volume, almost two thirds is non-heat-producing waste, while more than one third will be heat producing.

One uncertainty that influences the volume of HRA is the presence of operational nuclear installations in the Netherlands. In drawing up the inventory, account was taken of the closure of the nuclear power plant in Borssele in 2033 and the dismantling of that plant over the subsequent decades, and the construction of a research reactor in Petten (Pallas). Following the closure and dismantling of the nuclear power plant in Borssele, the volume of HRA produced each year will fall considerably.

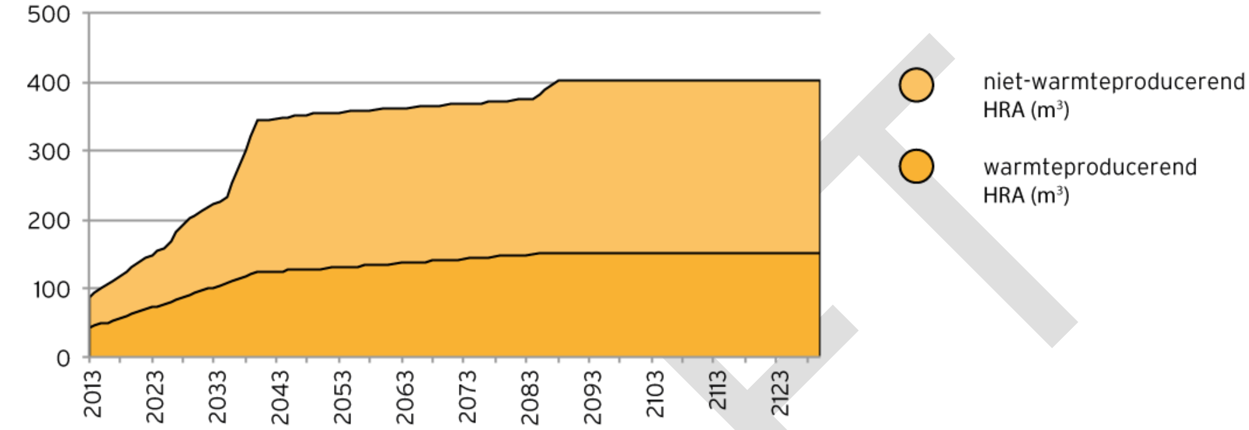

Figure 3.6 Development of the volume of HRA through to 2130.

LMRA

The volume of LMRA in 2130 is estimated at 70,000 m^3 (see figure 3.7). Of this total, approximately two thirds will decay over the next hundred years to below the exemption threshold. Decayed waste can be disposed of as conventional waste, and need not be placed in disposal.

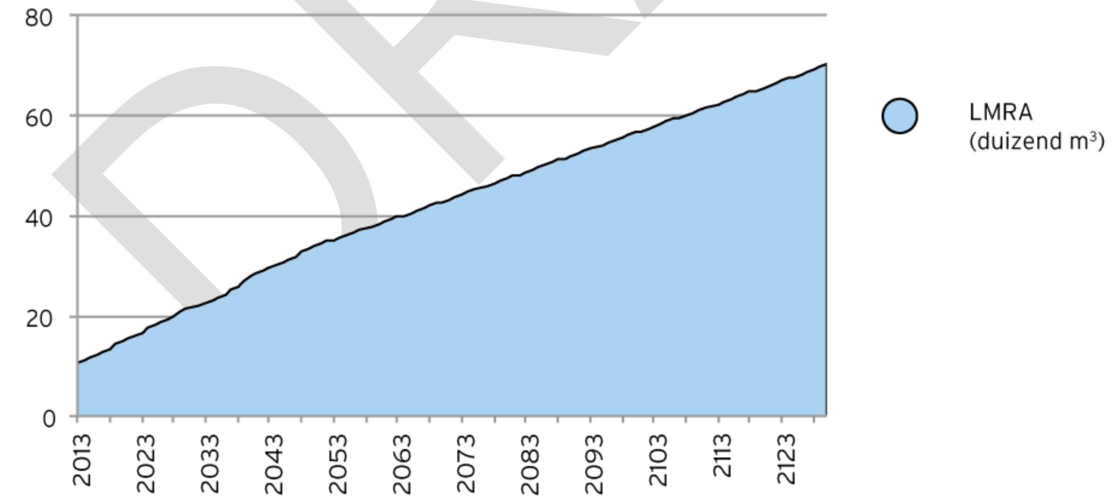

Figure 3.7 Development of the volume of LMRA through to 2130.

NORM

The volume of NORM waste in 2130 is estimated at 158,000 m^3 (see figure 3.8). Because of this huge volume, minor changes in legislation and regulations could bring about major fluctuations in the volume of NORM waste. Current production has been extrapolated into the future.

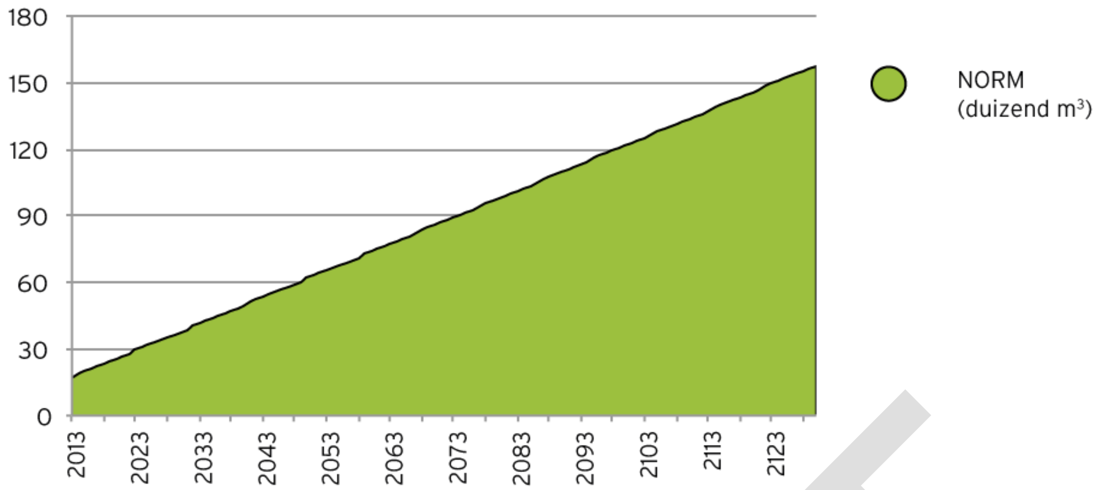

Figure 3.8 Development of the stored volume of NORM waste at COVRA through to 2130.

3.5 Other possible sources

At various locations and in different processes, radioactive waste substances can be expected. On the basis of a literature study, an indication is given below of whether radioactive waste could possibly be present (possible existing sources) or could be produced in the future (possible new sources) (see waste inventory). Any change in policy could also result in a change in the volume of waste. These aspects are discussed in more detail below.

Possible existing sources

Materials which were used in the past in industry or construction (such as certain types of slag wool) and minerals with high concentrations of radioactive substances (for example in museums or owned by private collectors) may contain radionuclides, as a result of which they must be disposed of as radioactive waste. Radioactive substances can also accumulate for example in different types of sludge, filter cakes, sewers at hospitals or industrial water boilers. It is also possible that fire alarms with a small radioactive source may still be in use, as well as thorium-bearing electrodes used in TIG welding. The use of thorium alloys in existing products and installations may also be a possible source of the production of radioactive waste.

Possible new sources

The construction of a new nuclear power plant could have major consequences for the future volume of radioactive waste. In addition, there are other possible technological developments which could result in new waste flows. New medical treatments could for example be developed whereby more or new radioactive sources are used. Ultra-deep drilling for example for geothermal energy could result in extra production of NORM waste. Examples from abroad show that water from far below ground may contain raised concentrations of radioactive substances which may be deposited in aboveground heat exchangers in the form of radioactive scale.

Changes to policy

Whether a waste material must be designated as radioactive depends on the release and exemption thresholds. Changes to these thresholds can lead to a change in the volume of waste. This is an important source of uncertainty in the extrapolation of volumes to the future. In addition, changes to the permitted disposal routes may result in changes in the expected volumes of radioactive waste. For example for more than 96% of the existing NORM waste that cannot be reused, dumping at special sites is considered a suitable definitive solution. Because of the large volume, future changes to this policy could have major consequences for the volume of NORM waste. Furthermore, at present, it is permitted to store waste that decays to below the exemption threshold within 2 years (half-life of less than 100 days) at the producer's own site, so that it can subsequently be disposed of as conventional waste. If this storage period changes, the volume of radioactive waste delivered to COVRA may rise or fall.

Part B – Policy

The policy for the management of radioactive waste is described in chapter 4. Chapter 5 then deals with legislation and regulations.

Chapter 4 – Policy principles

Since 1984, the management of radioactive waste has been based on the following principles:

- **Minimising the occurrence of radioactive waste;**
- **Safe management of radioactive waste;**
- **No unreasonable burdens on the shoulders of future generations;**
- **Causers of radioactive waste bear the costs for the management of that waste.**

These principles remain unchanged. This chapter describes how the principles have been elaborated in the policy on radioactive waste. An indication is also given of those points in respect of which the Cabinet has supplemented current policy.

4.1 Context

The policy on radioactive waste is part of the policy on nuclear safety and radiation protection. That policy is aimed at protecting man and the environment against the risks of exposure to ionising radiation. To achieve this, exposure to radiation must be justified, as low as reasonably achievable (ALARA) and must remain below specified values. Anyone employing ionising radiation bears first responsibility[12].

The same principles apply to the management of radioactive waste. This principle is further elaborated in chapter 4, sections 2 to 5.

A gradual approach

The policy, the regulations and supervision operate a gradual approach. This means: the greater the risk, the stricter the regime. The demands placed on actions involving fission materials, for example are more strict than actions using 'ordinary' radioactive substances.

Continuous improvement

Practice, policy, regulations and supervision must be continuously improved in order to comply with developing technologies and changing levels of understanding. For that reason, continuous improvement is laid down in the regulations relating to the licences issued to COVRA and other nuclear facilities. Every ten years, COVRA is required to carry out a detailed evaluation. An evaluation of all technical, organisational, procedural and administrative provisions must also be carried out every five years. If there are grounds for doing so, COVRA must take measures to improve safety.

Interfaces with other policy fields

- Conventional waste policy
  In radioactive waste policy, in elaborating the principle 'minimisation', broadly speaking, ties are sought with the policy for the management of conventional waste. In conventional waste policy, the aim is to close raw material cycles as far as possible. In this process, the Ladder of Lansink[13] is used to award priority to the most

[12] National policy on radiation protection and nuclear safety, Annex to Parliamentary Papers, session year 2014-2015, 25 422, no. 113.

[13] Named after the Dutch politician Ad Lansink who submitted a motion for this approach to the Dutch Lower Chamber, in 1979.

environmentally friendly management method. The policy on radioactive waste also assumes this preferential order for processing.

To achieve the safe management of radioactive waste, the policy has been focused on isolation, management and control (in Dutch the IBC principle). This principle is also applied for example in soil remediation.

- Nuclear safety policy
  For the management of spent fuel, the three principles from the nuclear safety policy are decisive: screening of radioactive materials and radiation, management of nuclear chain reactions and the cooling of fission materials. In managing spent fuels, it is essential that new chain reactions are prevented from occurring ('sub-criticality requirement). Furthermore, for heat-producing waste, sufficient cooling must be provided to guarantee the integrity of the packaging.

- Security and safeguards
  The security of radioactive waste substances is covered by the *Ministerial Regulations on Securing Nuclear Installations and Fission Materials*. These regulations describe the content and elaboration of the security of nuclear installations. These include the necessary and required alarm procedures, detection and response infrastructure, training programmes, etc.
  All Dutch nuclear installations, including COVRA, have an approved security package. This security package complies with the very latest international recommendations as laid down by the International Atomic Energy Agency (IAEA).

  On the basis of international non-proliferation treaties (*safeguards*), the Netherlands is required to take certain measures. The ANVS is also required to duly inform the IAEA. In this way, the IAEA can determine whether specific basic materials and special fission materials are not being used for producing nuclear weapons or other nuclear explosives, for example on the basis of material from radioactive waste.
  The Netherlands is also required to admit inspectors from the IAEA and the European Atomic Energy Community (Euratom), and to ensure that sanctions from Euratom are implemented. The ANVS makes sure that the Netherlands complies with all agreements, and the ANVS is the contact point for IAEA and Euratom inspections.

- Underground Structural Vision (Structuurvisie Ondergrond – STRONG)
  The underground environment below the Netherlands has a range of functions. Natural gas, drinking water and oil are for example produced from belowground and gas for example is stored belowground. To make the most efficient possible sustainable and futureproof use of the soil and underground environment, a structural vision is required. In the Underground Structural Vision, consideration is given to the use of the underground environment of the Netherlands through to the year 2040[14]. The geological disposal of radioactive waste is not included in this structural vision because such use is not planned until far later, well beyond the year 2040. An action point was added to the national programme, aimed at assessing whether the disposal of radioactive waste should be included in STRONG (see action point chapter 7.1.2). The preparation of this structural vision is the responsibility of the Minister of Infrastructure and the Environment working in close collaboration with the Minister of Economic Affairs.

4.2 Minimisation

4.2.1 Prevention and justification

The first principle in the policy on radioactive waste is that the production of radioactive waste should be limited by preventing the use of radioactivity as far as possible. A

[14] See www.rijksoverheid.nl/nrd-strong

licence or a report is required for the use of radioactivity (Nuclear Energy Act (Kew), art 29). One of the criteria for obtaining a licence is that the requested application is justified. This means that radioactivity may only be used if the economic, social and other advantages of the activity outweigh the potential health damage which can be caused as a result (Radiation Protection Decree (Bs), art. 4).
Even if the application is justified, the licence applicant still has the duty to prevent or restrict the production of radioactive waste materials as far as possible (Bs, art. 36). Furthermore, the operator is required to ensure that both the dosage in the event of exposure and the risk of exposure are kept as low as reasonably achievable (Bs, art. 5): the ALARA principle (*As Low As Reasonably Achievable*).

Minimising the volume of radioactive waste in the Netherlands is also a principle that applies to the unintended import of radioactive waste (for example when importing metal or scrap). The customs authorities use a detector to check whether imported material contains radioactive (waste) substances. If this is the case, the policy is that the material will be returned to the sender[15].

4.2.2 Reuse

The operator must as far as reasonably possible limit the production of radioactive waste wherever radioactivity is used (Bs, article 36). From the point of view of environmental hygiene, reuse is preferred to disposal (dumping and disposal). This can be achieved by reusing or separating radioactive components and/or decontaminating waste.

From an economic point of view, reuse offers opportunities, too. For that reason, reuse routes are in existence for a variety of radioactive waste substances, such as the smelting of contaminated or activated steel. The result is steel that can be reused, with a radioactive residual product that itself can sometimes also (in part) be reused. This for example is the process employed at steel foundries in Germany, Sweden and the United States. Following reprocessing, the radioactive (waste) materials are re-exported to the country of origin. NRG in Petten has an installation for removing radioactive precipitation from steel, and cleaning the steel. There are also a variety of routes for immobilising the radionuclides in NORM waste. Following forming and hardening, the material is then suitable for a variety of possible new applications.

To be able to answer questions in practical situations as to when materials, buildings and sites may be released for reuse, a guide is set to be prepared (see action point chapter 7.1.1). A guide is also to be prepared for the dismantling of non-nuclear installations. This guide contains regulations that can be used in closing and dismantling non-nuclear installations (see action point chapter 7.1.1). For the dismantling of nuclear installations, rules are already laid down in the *Radiation Protection Decree* and the *Nuclear Installations, Fissionable Materials and Ores Decree.*

The use of plutonium from reprocessed fuel rods in MOX fuel rods is another method of reuse, that furthermore reduces the plutonium stocks.

4.2.3 Radioactive decay

One property of radioactive waste is radioactive decay, see chapter 3.1. At a given moment, as a result of radioactive decay, the waste is no longer radioactive. Using this property is an effective means of ensuring less radioactive waste.
It is therefore legally permitted to allow radioactive waste with a half-life of less than 100 days to decay for a maximum of 2 years at the premises of the operator, until it falls below the release thresholds (Bs, article 38, paragraph 4). It can then be removed as conventional waste. This option is regularly used with radionuclides with a short life, for example in hospitals and laboratories (see chapter 3.3 *Short-lived waste*).

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[15] Inspection guidelines metal and scrap containing radioactive substances September 2013

New additional policy: decay storage

There are forms of radioactive waste that require several tens of years to decay to below the release threshold values. According to current regulations, this waste must be stored at COVRA (Bs, art. 37) to be conditioned for disposal. However, some of this material is potentially valuable, such as metals or rare earth elements, that could be reused.

The Cabinet has set itself the goal of achieving a circular economy, and wishes to stimulate the (European) market for renewable raw materials and the reuse of scarce material[16]. This goal includes policy that makes it possible to return valuable (raw) materials that are no longer radioactive to the raw material cycle, rather than storing these materials in a disposal site.

In a decay storage, materials that need more than two years to decay below the release thresholds can be stored safely. For that reason, since 2014, materials originating from the dismantling of large permanent installations (such as cyclotrons) can be stored unprocessed at COVRA for a period of not more than 25 years, if within 25 years the activity level of the waste decays to below the current release thresholds. These materials can then be reused as raw materials.

Certain materials need even longer to decay below the release thresholds. It is also possible that material other than dismantling waste could be suitable for decaying to below the release thresholds, in a decay store. Investigating the possibility of expanding the delay storage of these materials at COVRA is an action point in this programme (see action point chapter 7.1.1).

4.2.4 Incineration

In certain cases, it is possible to safely incinerate radioactive waste, whereby the radioactivity remains behind in the filters and the ash. This is for example the case with contaminated cadavers from research, and can result in a considerable reduction in the volume of this radioactive waste. In the Netherlands, a very small volume of radioactive waste is incinerated at COVRA.

4.2.5 Reprocessing

By reprocessing high level radioactive waste, the volume and life of the waste are limited. It is up to the licence holder of a nuclear reactor to choose between immediate storage or reprocessing of irradiated fuel. From the point of view of environmental hygiene, safety and non-proliferation, there is no decisive preference for one of these options[17]. In the case of a new nuclear power plant, the licence holder will have to evaluate the 'back-end' strategy every ten years. Central government does the same every twenty years. Depending on these evaluations, a different strategy may subsequently be imposed on the licence holder. Even in the case of reprocessing, the operator remains responsible for the safe storage of radioactive waste (Bkse, article 30f).

Reprocessing
Still usable substances are left behind in the spent fuel rods from the nuclear power plant Borssele. The operator of the Borssele nuclear power plant (EPZ) has opted to have these materials recovered (known as reprocessing). The spent fuel is sent for that process to a reprocessing plant (La Hague in France) where the usable components (95%) are separated out of the radioactive waste, for reuse. The radioactive waste (5%) is packed in glass (vitrified) and returned to the Netherlands to be stored at COVRA.

[16] Coalition agreement *Bruggen slaan (Building bridges)*, 2012.
[17] Parliamentary papers, session year 2010-2011, 32 645, no. 1.

The usable components include the long-lived plutonium that is responsible for the very long decay time for the spent fuels. By separating out this plutonium, the remaining volume of radioactive waste has a far shorter life. Instead of quarter of a million years, this material takes approximately ten thousand years to decay to the level of the original ore.

4.3 Safe management now and in the future: storage and disposal

The second principle behind the policy on radioactive waste is that radioactive waste must be managed safely as long as it represents a risk to man and the environment. In the Netherlands, the chosen option is central storage for a period of at least 100 years in buildings, after which time disposal is envisaged. This disposal facility should be operational by around 2130. The rationale behind a period of at least 100 years is that this period is necessary in order to save sufficient waste and sufficient money to create a disposal site.

Storage and disposal
The management of radioactive waste can be divided into two periods, one of storage and one of disposal (also known as simply disposal). The difference between the two is that storage is always temporary in character while the intention with disposal is that the radioactive waste should not be removed from the disposal facility at any point in the future.

4.3.1 Safe management now: storage

Radioactive waste is produced at various locations in society. The Netherlands has a limited volume of radioactive waste as compared to countries with more nuclear installations. To achieve the safe management of the radioactive waste, the policy is focused on isolating, managing and controlling (IBC principle). For the management of radioactive waste, specialist measures, infrastructure and expertise are essential. In the Netherlands, the decision was taken in 1984 to entrust the allocation of this policy to a single specially established organisation, the Central Organisation For Radioactive Waste (COVRA) (see annex D). The central collection, processing and storage of radioactive waste also ensures the fulfilment of other key aspects such as environmental hygiene, cost effectiveness and occupational hygiene.

Radioactive waste must be transported to COVRA as soon as reasonably achievable. COVRA has been authorised for the collection and reception of radioactive waste[18]. The operator transfers all responsibilities for the waste to COVRA, at the moment that the waste is collected by COVRA. As a result, COVRA becomes owner of the radioactive waste. At the COVRA site, the waste is stored aboveground for at least 100 years in specially designed buildings. The special feature of the waste packaging employed and these buildings is that in the design of the construction work, account was already taken of a period of at least 100 years. This storage method is unique in the world.

The period of aboveground storage for at least 100 years offers the following advantages:

- Over the period of 100 years, the volume of radioactive waste that has to be disposed of can grow, as a result of which operating costs per unit of waste could be restricted, in addition to which new technical advances could take place for the most efficient and cheapest method possible of disposing of the waste. The period of 100 years can also be used for allowing money placed in a fund to accumulate. The aim is to use this money to cover the costs for the long-term storage and the

[18] Decree on the Recognition of COVRA as collection service for radioactive waste materials, fission materials and ore-bearing waste substances. ##link verloren

preparation, construction, operation and closure of the disposal facility (see chapter 4.5.3);

- Within the period of 100 years, part of the radioactive waste will decay to below the release threshold. As a result, this part of the waste need no longer in principle be placed in the disposal, and may possibly be suitable for reuse;
- During the period of aboveground storage, the heat-producing waste will cool to a temperature at which it is easier to handle and to dispose of;
- Since no choice has yet been made for a location for the disposal facility, this period can be used to make a selection of a suitable location in consultation with society;
- There is more time to learn from experience accrued abroad in building and operating disposal facilities;
- There is more time to carry out research into the best management method for the long term;
- In the future, international (for example regional disposal in Europe) or new technical solutions could become available (such as partition and transmutation whereby long-lived radionuclides are separated and converted into shorter-lived radionuclides). By storing radioactive waste aboveground for the time being, these new solutions can then be relatively simply deployed;
- Future generations will be given an opportunity to choose a long-term management method on the basis of their own understanding, with the least possible burden.

Following the period of aboveground storage of radioactive waste at COVRA, geological disposal for HRA, LMRA and NORM waste is planned. Table 4.1 provides an overview of the interim and definitive management methods for the various categories of radioactive waste. Radioactive waste which following storage at COVRA remains radioactive, will be placed in a disposal facility. If the radioactive waste has decayed to below the release thresholds, it can be released for reuse or processed as conventional waste. This applies to two thirds of the LMRA stored at COVRA.

<table>
<tr><th>Category radioactive waste</th><th>interim management method</th><th>followed by</th></tr>
<tr><td>HRA</td><td>aboveground storage</td><td rowspan="3">geological disposal</td></tr>
<tr><td>LMRA</td><td>aboveground storage</td></tr>
<tr><td>NORM</td><td>aboveground storage</td></tr>
<tr><td>Waste subject to compulsory reporting</td><td>-</td><td>dumping at landfill</td></tr>
<tr><td>Radioactive waste with $T_{1/2} \leq 100$ days</td><td>storage on location</td><td rowspan="3">reuse or reprocessing as conventional waste</td></tr>
<tr><td>Radioactive waste that decays to below the release thresholds within 25 years</td><td>aboveground storage</td></tr>
<tr><td>Radioactive waste below the release thresholds</td><td>-</td></tr>
</table>

Table 4.1 Overview of management routes.

4.3.2 Safe management in the future: (definitive) disposal

HRA and long-lived LMRA must be managed for many thousands or even hundreds of thousands of years before the radiation levels have fallen to such an extent that they no longer represent radiation risks. Aboveground storage is not viewed as a suitable manner of managing radioactive waste for such a long period. There is after all no guarantee that the chain of active management necessary for aboveground storage will or can be maintained over such a long period. Passive safety is one means of guaranteeing safety over a longer period. This passive safety is achieved by means of geological disposal. For that reason, also on an international scale, geological disposal is viewed as the only safe means of managing long-lived radioactive waste for the long term. In the case of disposal, it must be demonstrated that the population is sufficiently protected against the effects of exposure to radiation, now and in the future, in all stages of waste management. This extends to include the quality of the groundwater and the drinking water extracted therefrom. See the block on Geological disposal.

Geological disposal

The Earth is made up of different layers or strata. Some of these layers deep underground have been stable for millions of years. There is international consensus that stable geological layers are suitable for the disposal of radioactive waste. In the Netherlands, certain clay layers and rock salt layers/domes are in principle suitable for geological disposal. The remarkable feature of these layers is that they are self-healing; should empty spaces or cracks in the geological layer occur during the excavation of the disposal site, these will simply disappear due to the plasticity of the layer.

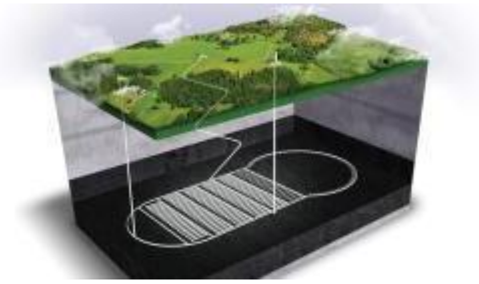

Figure 4.2 Illustration of a disposal concept currently under investigation in the OPERA research programme.

The radioactive waste will be carefully placed in excavated galleries, taking account of the volume of heat and radiation still being released by the waste. Following the placement of the waste, the galleries will be backfilled in phases, so that the geological layer becomes a compact unit (closure of the disposal facility).
Following closure of the disposal facility, it will be considered passively safe. This means that future generations are no longer required to manage or maintain the disposal facility.

Humans will be protected by placing a series of barriers (both natural and artificial) between the radioactive waste and the human environment: enclosure, delay and isolation. The packaging of the waste is an artificial barrier that ensures that the waste is enclosed. The packaging materials are designed in such a way that they enclose the waste for the first few thousand years. Over this time, the heat-producing waste will cool down, and the remaining waste will decay, resulting in an ever lower radiation burden. At the point in time when the packaging degrades, the clay or salt layer will ensure that the radionuclides move towards the surface at a delayed rate. Radioactive decay means that most radionuclides will not even reach the surface. In addition, the depth of the geological disposal forms the final barrier: isolation from the human environment. In this way, people and animals cannot access the disposal facility, and the depth also protects against human penetration.

International research has shown that methods are available for adequately determining the long-term safety of geological disposal. Since that time, these methods have been improved by further development. The safety case, in which the evidence for safety is considered in its entirety, is an example of the further development of these measures. Knowledge of the underground environment is combined internationally, in order to gain a greater understanding of the behaviour of that environment and of the processes and issues which could disrupt the safe disposal of radioactive waste, and how this might happen.

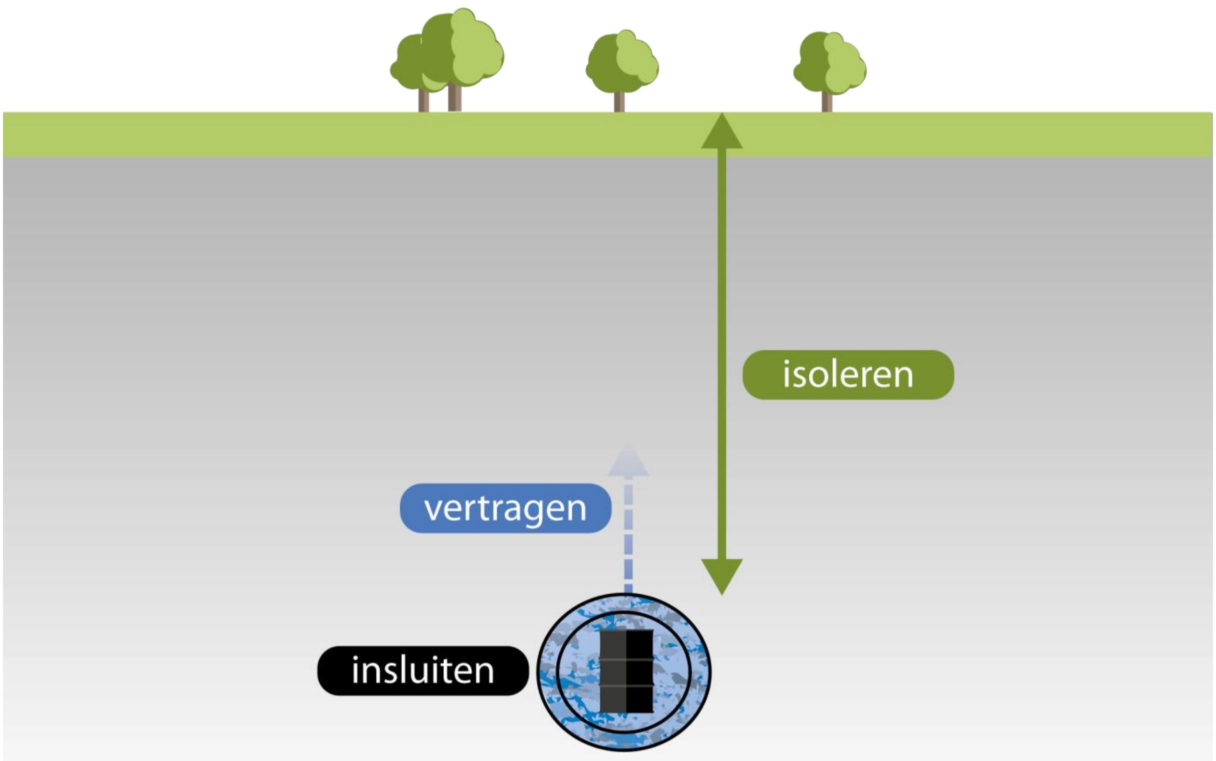

Figure 4.3 Multiple safety functions of geological disposal (source: COVRA).

Internationally[19], geological disposal is viewed as the best method for safe management of radioactive waste in the long term. Because the choice for geological disposal was taken several decades ago, in Dutch policy, in an initial study underpinning this national programme, the latest international thinking on the options for the management of radioactive waste in the long term – together with the advantages and disadvantages of the options chosen – have once again been outlined for the Dutch situation (see initial study). The outcomes of that study together with the international consensus on disposal give no grounds to revise current policy.

Various options for the management of radioactive waste are rejected on the basis of treaties, statutory, technical and/or ethical grounds (including for example sending nuclear waste to the moon, dumping at sea or disposal in an icecap). Long-term aboveground storage, surface disposal, geological disposal and disposal in deep drillings are further investigated in the study. The advantages and disadvantages of these latter options have been charted out, together with the effect of multinational disposal and partition and transmutation.

The following conclusions can be drawn from the initial study:

- Long-term aboveground storage is not suitable as disposal of radioactive waste. Although this technique has already been employed for intermediate storage at various locations, it requires continuous active management.
- Surface disposal is only suitable for short-lived LMRA and not for long-lived LMRA and HRA, because given the long-term nature or radiation levels, storage must be carried out deeper belowground in order to guarantee the required levels of passive safety.
- Worldwide, a number of surface disposal sites are already in use for short-lived LMRA. This technique is considered less suitable in the Netherlands, because of the high groundwater levels and the limited space available. The small volume of

[19] For an overview of international organisations, see annex E.2.3.

waste and the high costs for disposal result in a preference for creating a single disposal facility, in which all the radioactive waste can be placed.

- As yet, disposal in deep drillings has not been employed anywhere; much research will still be required into this method. Waste will be very difficult to retrieve from deep drillings. In this way this requirement does not comply with the requirement for retrievability (see 4.3.3).
- Nowhere in the world has geological disposal been carried out for heat-producing high level radioactive waste, although programmes are underway in various countries (including Finland, France, Sweden, Switzerland) for creating geological disposal facilities. The possibility of retrieving the waste, and the disposal of all the waste in a single facility makes this technique suitable for (all) Dutch radioactive waste.
- Creating a multinational disposal facility offers clear advantages. These include lower costs for creating the disposal facility, more choice of possible suitable locations, the combining of technical capacity and supranational supervision. Furthermore, for each disposal type, diversity can be achieved in waste types. The disadvantages of multinational disposal are (among others) the necessity to transport the radioactive waste over longer distances, deviation between (national) legislation and definitions, cost sharing among the partners, different timetables and locations from where the waste will be delivered.
- The one-time investment costs for the construction of aboveground storage are lower than for building a geological disposal facility. However, because in this management option the costs are not one-off costs but are likely to have to be renewed every 100 to 300 years, in the long term these costs are far higher than for geological disposal.
- In the case of partition and transmutation (P&T), the life of the radioactive waste is shortened. However, this technique is still in the development stage: further development is required before it can be used on a large scale. P&T is not a standalone technique but instead is part of a chain of nuclear energy techniques (enrichment, reactors, reprocessing). A disposal facility will also always have to be created for the residual waste. Partition and transmutation are in principle not suitable for already vitrified HRA or LMRA.

New supplementary policy: dual strategy

Cooperation between European Member States in the field of disposal of radioactive waste can offer clear advantages. For this reason, international cooperation is not excluded as an option for creating a disposal facility. In this so-called 'dual strategy', attention will be focused on two policy lines, creating our own national disposal facility and an international disposal facility.

Cooperation between countries in the field of radioactive waste management will result in cost savings. There are also advantages in respect of the exchange of knowledge and innovations. This applies in particular to the disposal of radioactive waste. Disposal, certainly for a country with a small nuclear sector, is the most costly step in the management of radioactive waste[20].

Cooperation could result in international transport of radioactive waste. The supervision and monitoring of the transfer of radioactive waste and spent fuel is regulated on a European scale, in Directive 2006/117/Euratom. The Directive lays down clear rules for the export of radioactive waste for the purposes of disposal. For example, radioactive waste may only be transported to countries outside the European Union if a disposal facility is already operational in those countries. For the import and export of radioactive waste, see the section below 'new supplementary policy: conditions for import and export'.

[20] Parliamentary papers, session year 2012-2013, 25 422, no. 105.

New supplementary policy: investigation of conditions for import and export

In parallel to the efforts aimed at international cooperation, the possibility and desirability of imposing conditions on the import and export of radioactive waste substances for storage and/or disposal in the Netherlands will be investigated. The current storage capacity at COVRA has been dimensioned to handle the expected Dutch demand for storage capacity for the coming period of at least 100 years. By imposing preconditions, a well-balanced decision can be taken on whether an increase or reduction in the volume of radioactive waste at COVRA may be desirable. The investigation of the preconditions to be imposed on import and export is an action point in this programme[21] (see action point chapter 7.1.1).

New supplementary policy: flexibilisation of the timetable and disposal method

Developments may take place in the future, such as innovations or international cooperation in creating a disposal facility, as a result of which society will want to deviate from the selected timetable of at least 100 years aboveground storage at COVRA. For that reason, this possibility will be left open. Because radioactive waste is stored aboveground, it is possible in the Netherlands to deal flexibly with the timetable.

For short-lived low level and intermediate level radioactive waste, in principle disposal at the surface is also sufficient. The possibility will be kept open of flexibly responding to the choice for the long-term management option.

Until a change is made in the existing policy line for the timetable and disposal method, however, the programme aimed at creating a national geological disposal facility will be continued. Given economies of scale, it is expected that all types of Dutch radioactive waste will in the long term be placed in geological disposal[22].

4.3.3 Safe management in the future: retrievability

Retrievability is a precondition for the management of radioactive waste in a disposal facility. Research in the past has shown that it is possible to create a retrievable geological disposal facility in clay and salt, for a period of one hundred through to several hundreds of years[23].

Retrievability and passive safety

At present, radioactive waste is stored aboveground, retrievably, at COVRA. The waste is safely stored and available if new processing or management techniques become available. A disadvantage of this method of storage is that it is sensitive to external influences (for example climate change or war). In addition, this management method requires active management: during the entire management period, a waste management organisation will be required that bears responsibility for the safe management, and a government that supervises the work of this waste management organisation. Because there are no guarantees in the future that society will be able to maintain the same level of active management, passive management is needed for the long term. This change will also reduce the burdens for the management of radioactive waste, for future generations.

[21] Parliamentary papers, session year 2012-2013, 25 422, no. 105.

[22] Parliamentary papers, session year 2012-2013, 25 422, no. 105.

[23] Final report of the Committee on the Storage of Radioactive Waste, February 2001, *Retrievable disposal, a viable pathway?*

Passive safe management

Passive management means the enclosure and isolation of radioactive waste in such a way that current and future generations are not required to make any further effort to maintain safety. Geological disposal is one of the management options that following closure offers passive safety. The opposite to passive safe management is active management. In an active management option, such as aboveground storage, constant management by people is needed in order to guarantee protection of man and the environment.

Even in geological disposal, the waste must be retrievable for a certain period. Below, a number of advantages and disadvantages of retrievability are outlined, in respect of safety aspects.

Retrievability has the following advantages:

- The radioactive waste in the disposal facility is available for reuse if possibilities that are not yet available become available. If those possibilities arise, the waste can be returned to the chain in a manner that is environmentally hygienically responsible. This retains the freedom of future generations to act;
- In the period in which the disposal facility has not yet been closed, and the waste is still retrievable, it is possible to assess whether the geological disposal facility is functioning as expected. Any necessary changes can then be made.

Retrievability also engenders a number of disadvantages:

- During the period of retrievability, the waste can be retrieved because the geological disposal is not yet closed. In other words, there is not yet a situation of passive safety. Effectively, in this period, the disposal facility is an underground store;
- Keeping the disposal facility open requires active management by man over a longer period: maintenance of the geological disposal facility, supervision of safety, security of the geological disposal facility, data management and maintenance of the necessary expertise to manage the disposal, for closure in the future;
- It is possible to dispose of drums in such a way that they can be retrieved over a period of several hundred years. Retrieval of drums however engenders additional costs. Depending on the phase in which the geological disposal facility is found, these costs may vary: over time, the costs rise. (On the other hand, the retrieval of waste from a disposal facility designed for that purpose will be cheaper than from a facility not designed for that purpose.) Keeping the geological disposal facility open also costs money. Estimates for keeping a geological disposal facility open in clay or salt are being updated in the OPERA research programme. In the past, they were estimated at approximately 1.8 million euro per year[24,25].

There is a relationship between the ease of retrievability of radioactive waste from the disposal facility versus the costs of retrieval and the aspects of safety in respect of passive versus active monitoring during the term of disposal. Retrievability is a property of a geological disposal facility. In a step-by-step process, the degree of retrievability changes over time. In the long term, the behaviour of a retrievable disposal facility is no different from that of a non-retrievable facility. This is reproduced in diagrammatic form in figure 4.4.

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[24] Parliamentary papers, session year 2002-2003, 28 674, no. 1.

[25] Final report of the Committee on the Storage of Radioactive Waste, February 2001, *Retrievable disposal, a viable pathway?*

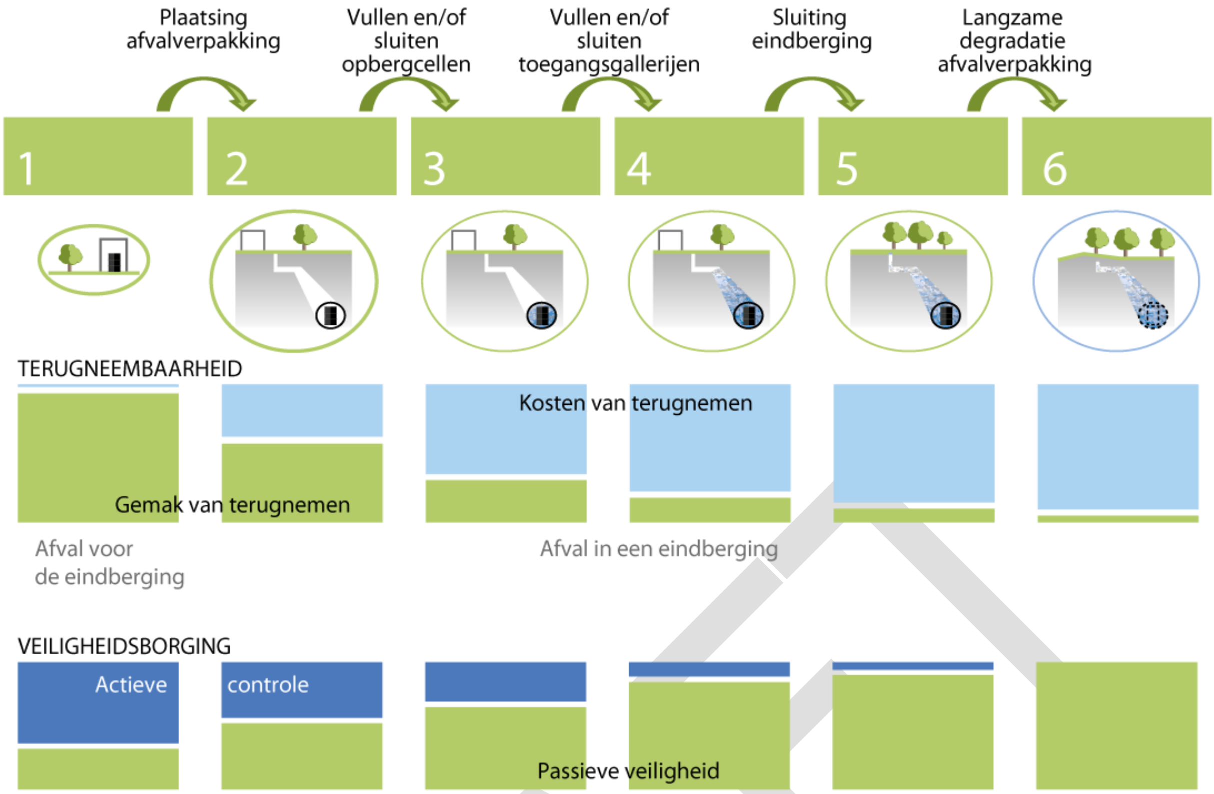

Figure 4.4 Different stages of a geological disposal facility in relation to the changing degree of retrievability, passive versus active monitoring and the costs of retrieval of radioactive waste (source: COVRA, based on a figure from OECD/NEA).

Period of retrievability

In order to enjoy the greatest possible profit from the advantages of retrievability and the advantages of a passive, safe (closed) disposal facility, a balance will have to be identified. The purpose of disposal is after all the definitive removal of waste, not the underground storage of waste. In a disposal facility, therefore, no radioactive waste should be placed that is expected to be reusable in the future. The facility should not be put into use, if there is insufficient confidence in the safety of long-term disposal.

New supplementary policy: period and method of retrievability

At the end of the day, in consultation with society, it will be important to assess the optimum period of retrievability (see action point chapter 7.1.2). Under all circumstances, radioactive waste must be retrievable during the operational phase of the disposal facility through to its closure[26].

At the point in time when a disposal facility is to be created – in the Netherlands around 2130 – society will be able to impose demands on the retrievability of the definitively disposed material. Until the disposal facility is fully closed, each generation then in life will be able to reconsider whether the disposal facility should be kept open or closed. Following definitive closure of the disposal facility, the waste will no longer be retrievable via the original shafts and gangways. Given the development of drilling techniques, it will of course at all times be eventually possible to retrieve the waste, but the costs of retrieval could be very high. Experiences in countries in which a waste disposal facility is already operational can then be taken into account.

[26] Parliamentary papers, session year 2013-2014, attachment no. 36.

Retrievability in an international perspective
On an international scale, different periods of retrievability are maintained. Each country makes its own choice. The choice is often made according to the phase in which the disposal facility finds itself. Retrievability is often demanded during the operational phase, but no longer required once the facility is eventually closed. The period of retrievability depends on the intention of keeping the geological disposal facility open. In fact, not all countries operate a concept of retrievability.

4.3.4 Safe management in the future: monitoring and knowledge assurance

When it comes to disposal, monitoring and knowledge assurance are also important. These aspects are relevant at different moments of the process of creating a disposal facility. There are many international developments in these fields, and a great deal of progress is expected, because the first disposal facilities for high level radioactive waste have not yet been commissioned. It is important that the Netherlands remains up to date on these developments. This is achieved in the Netherlands through research, tying in with international studies and consultation groups in which the knowledge and results are shared. Annex E provides more information about monitoring, knowledge assurance and research.

4.3.5 Expertise and competence

To facilitate the safe management of radioactive waste, it is essential that the people dealing with the waste are sufficiently qualified. The relevant rules are contained in the general policy on radiation protection. Dutch legislation and regulations[27] contain instructions for the responsible handling of ionising radiation. Activities and actions involving ionising radiation, therefore including activities involving radioactive waste and spent fuel, may only be carried out by or subject to the supervision of persons with sufficient expertise in the field of radiation protection (Bs, paragraph 3.1). With the implementation of the European basic standards (2013/59/Euratom) in February 2018, that expertise will be further secured. The Dutch system of expertise will be adapted for the implementation of the BSS. In particular, training for the supervisory expert will be extended to include knowledge of the specific application.

4.4 No unreasonable burdens for future generations

The third principle in the policy on radioactive waste policy is that no unreasonable burdens may be imposed on future generations. Generations that have profited from a specific application of radioactivity, such as nuclear power or medical isotopes, must themselves bear the burdens for managing the waste produced in those activities. To prevent the burden for the management of waste being placed on future generations, a passively safe management method will have to be achieved (see the box on Passive safe management). It is essential in this respect that future generations have sufficient knowledge (see annex E) and financial resources (see chapter 4.5) to establish, operate and close a disposal facility).

The period of retrievability (see 4.3.3) offers future generations the possibility of retrieving waste from the disposal facility if new techniques for waste processing or management become available. The reversible structuring of the process for (definitive) disposal will also relieve future generations from the burden of decisions taken in the past (see chapter 6).

[27] Legislation and regulations (see www.wetten.overheid.nl): the Nuclear Energy Act, the Decree on radiation protection (Bs), the Implementation regulations on radiation protection Economic Affairs and the individual licences.

4.5 Costs of management for causers

The fourth principle in the policy on radioactive waste is that in respect of all costs involved in the management of the radioactive waste, 'the polluter pays' principle will apply. This principle will be fulfilled by the fact that COVRA will include in its charges all estimated costs for processing, storage and disposal, on the basis of the state of the art at that time. Following delivery, the legal ownership of the waste and the related (financial) risks are transferred to COVRA. The risk that insufficient resources will be available in the future among waste producers, the long-term existence of which is uncertain, is limited in this way.

A series of measures have been taken to ensure that sufficient financial resources are available for the safe management of radioactive waste. The financing schemes are laid down in the regulations based on the *Nuclear Energy Act*. There are also private agreements (contracts) between businesses and COVRA.

4.5.1 Responsibilities of the operator

The operator is required to take measures to guarantee the safety of man and the environment, as long as he has in his possession or processes radioactive (waste) substances. These are organisational measures, for ensuring sufficient (radiation) expertise and keeping administrative records, as well as physical measures such as a storage location with sufficient protection and limited access. If no further processing is necessary or possible, the waste must be transported to COVRA as quickly as reasonably possible. This also applies for waste released during the possible dismantling of an installation or facility and during reprocessing. COVRA charges all costs for the collection, processing, storage and disposal to the operator. In practice, the higher costs for the management of radioactive waste are an important reason why an operator will voluntarily work towards preventing the production of waste. For this reason, no (additional) financing schemes are necessary in relation to waste prevention. A number of specific responsibilities that are held by the operator are listed below.

Reprocessing spent fuel

The choice of whether or not to reprocess spent fuel is left to the operator. Research[28] has revealed that from the perspective of environmental hygiene and safety and non-proliferation, there is no decisive preference for reprocessing or immediate storage. In other words, the operator is free to make a choice on the basis of economic considerations.

Financial security

All costs for the management of radioactive waste are part of the *business case* of the operator. However, the possibility cannot be excluded that following a disaster or bankruptcy, an operator will not have sufficient financial resources to safely manage and dispose of any radioactive waste or spent fuel present at that moment. For operators working with large volumes of scrap or highly active sources, and for licence holders for nuclear reactors, legal obligations have been laid down for (securing the) financing of management for the waste. Licence holders for nuclear reactors, for example must offer financial security for the costs of dismantling their facility (KEW, article 15f) in a manner approved by the Minister of Infrastructure and the Environment and the Minister of Finance. Part of the specific costs for supervision and for licencing are charged on to the nuclear sector (*Nuclear Power Act (Payments) Decree*). The operators of nuclear power plants in Borssele and Dodewaard are in possession of insurance that covers the costs of early dismantling if made necessary as a consequence of a disaster.

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[28] Parliamentary papers, Session year 2004–2005, 30 000, no. 5; Parliamentary papers, Session year 2005–2006, 30 000, no. 18; Parliamentary papers, Session year 2006–2007, 30 000, no. 40; Parliamentary papers, Dutch Lower Chamber, Session year 2009–2010, 31 510, no. 40.

The bankruptcy of Thermphos made it clear that the costs of closing down a business that deals with radioactive substances can be high. During discussions with the affected companies, the introduction of a termination plan is examined. This plan must include an assessment of the financial aspects of termination (see action point chapter 7.1.1).

Historical waste in Petten

At the research location in Petten, a volume of historical radioactive waste that predates the establishment of COVRA is still present. The costs for transporting this waste to COVRA are for the account of the owner, the EnergieonderzoeksCentrum Nederland (ECN). These costs include adapting existing installations for the repacking of the waste for transport, transport to third parties for treatment of the waste, treatment of the waste by third parties, transport to COVRA and the costs charged by COVRA for the storage and (definitive) disposal (see action point chapter 7.1.1). The Ministry of Economic Affairs has awarded a grant to ECN for the disposal of the historical waste.

4.5.2 COVRA

The task of COVRA is to manage Dutch radioactive waste, now and in the future. The costs incurred by COVRA in managing radioactive waste are charged on to the suppliers of the radioactive waste. These costs break down into:

- Operating costs for the aboveground storage and the collection, conditioning and storage of waste, including buildings and operating costs such as staff costs and business management costs;
- Long-term costs for the ability to create, operate and close a disposal facility, including the costs for research and development for the facility (see 4.5.3).

4.5.3 Financing the disposal facility

The estimated costs for creating a disposal facility will be charged on by COVRA to the suppliers of the waste, in the costs charged by COVRA. These costs will be charged for both low level and intermediate level radioactive waste, and high level radioactive waste that will be stored in the disposal facility.

The funds provided will be invested so that they will be able to grow during the period of aboveground storage. The aim is to cover the costs for the preparation, construction, operation and closure of a geological disposal facility following the period of aboveground storage. At present, COVRA invests a large proportion of its funds with the State via treasury banking. The Board of Supervisory Directors is responsible for supervising the business, and considers the growth of the resources for long-term storage and disposal, subject to a five-year interim assessment, in which the current operating principles for example in respect of return on investment are assessed. A new cost estimate for a disposal facility will be drawn up within the OPERA research programme.

The ‘polluter pays’ principle also applies for the financing of the necessary research into disposal. The current OPERA research programme comes to an end in 2016. The financing of this programme is beyond the scope of the COVRA charges, but the financing of any necessary follow-up research for the development and creation of a disposal facility must be included in the charges levied by COVRA. This obligation was introduced with the implementation of the *Directive 2011/70/Euratom*.

Chapter 5 – Legislation and regulations

This chapter provides a brief description of Dutch regulations relating to the management of spent fuel and radioactive waste. The chapter also provides a brief description of the two agreements entered into between the Netherlands and France and the United Kingdom for the reprocessing of Dutch spent fuel.

5.1 Dutch legislation and regulations on radioactive waste

5.1.1 Nuclear Energy Act

The Nuclear Energy Act is the basis of Dutch regulations in respect of nuclear safety and radiation protection, and as such for the management of spent fuel and radioactive waste. The Nuclear Energy Act contains more than 100 articles. These articles lay down the foundations for further regulations, licensing systems and the authorities of the government.

In addition to the Nuclear Energy Act, a number of other Acts apply to the management of spent fuel and radioactive waste. These Acts for example legislate on liability in the event of accidents with nuclear facilities, authorities of supervisors, public access, consultation and legal protection.

5.1.2 Governmental Decrees and Ministerial regulations

For the management of spent fuel and radioactive waste, the following Governmental Decrees are particularly important:

- The *Radiation Protection Decree* (Bs): this describes the most important rules for handling radioactive waste substances;
- The *Nuclear Installations, Fissionable Materials and Ores Decree* (Bkse): this Decree lists the most important rules for handling spent fuel;
- The *Transport of Fissionable Materials, Ores and Radioactive Substances Decree* (Bvser): in this Decree, the transport of both spent fuels and radioactive waste materials are regulated.

For more detailed rules, a set of Ministerial regulations applies.

5.1.3 Licences

In addition to the above rules that apply to all parties, the Nuclear Energy Act also features a series of systems of licencing. There are separate licences for operating a nuclear facility, undertaking an activity with a radioactive substance, using an facility or for the transport of fission materials or a radioactive substance. Characteristic for the regulations in a licence is that they are specific to the licence holder. If necessary, for a particular application, a 'bespoke' agreement can apply. In comparison to the situation abroad, a relatively large number of issues are settled in the system of licencing.

5.1.4 European Directives

The Netherlands, as a Member State of the European Union, is required in its own national system of regulations to implement those Directives that are established in collaboration with the other Member States. In this way, Directive 2011/70/Euratom – the Directive on which this national programme is based – was implemented in the *Radiation Protection Decree* (article 20h) and in the *Nuclear Installations, Fissionable Materials and Ores Decree* (article 40a).

5.2 Intergovernmental agreements

The Netherlands has entered into an agreement with two Member States, France and the United Kingdom, concerning the reprocessing of spent fuel originating from the Netherlands.

5.2.1 Agreement with France

In 1979, the Dutch and French governments signed an agreement in which the possible return to the Netherlands of spent fuel originating from the Borssele nuclear power plant following reprocessing is organised[29]. The Netherlands agreed to implement no statutory measures or draw up regulations which prevent COGEMA (now AREVA NC) from returning the radioactive waste produced during reprocessing to the Netherlands. COGEMA (now AREVA NC) is the organisation responsible for reprocessing the spent fuel.

In 2006, a change to the law was introduced in France according to which the import onto French territory of spent fuel for the purpose of reprocessing is only permitted in the framework of an intergovernmental agreement[30]. That agreement must specify that following reprocessing, the remaining radioactive waste will no longer be stored in France than the date contained in the agreement. In 2009, the Netherlands and France agreed on an amendment to the 1979 agreement in which this is laid down[31]. However, these agreements are restricted to spent fuels from the nuclear power plant in Borssele, which at the latest by 2015 will be supplied to AREVA for reprocessing.

Because of the extension of the operating period for the Borssele nuclear power plant until at the latest the end of 2033, it was necessary to establish a new agreement between the Netherlands and France for the importing into French territory of spent fuel[32]. In the agreement, it is determined that the spent fuel from the Borssele nuclear power plant can be reprocessed at AREVA. This spent fuel must have been imported into France between the moment at which this agreement becomes effective, and at the very latest 31 December 2049 (in connection with the dismantling). The Netherlands has accepted the obligation to take back the waste that is left behind following reprocessing. The last return delivery of radioactive waste must have taken place at the latest by 31 December 2052.

5.2.2 Agreement with the United Kingdom

In 1978, the Dutch government entered into an agreement with the United Kingdom for the possible return delivery following reprocessing of the residual radioactive waste from GKN Dodewaard[33]. The last delivery of radioactive waste from GKN Dodewaard has now been returned to the Netherlands, and is stored at COVRA.

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[29] Correspondence between the Government of the Kingdom of the Netherlands and the Government of the French Republic relating to an agreement in respect of the possible return delivery of the radioactive waste remaining following the reprocessing of irradiated reactor fuel, Paris, 29 May 1979.

[30] L.542-2 and L.542-2-1-I of the Code of Environmental Matter.

[31] Agreement between the Government of the Kingdom of the Netherlands and the Government of the French Republic concerning amendment to the Agreement of 29 May 1979 concerning the reprocessing in France of irradiated fuel elements, Paris, 2 September 2009.

[32] Agreement between the Government of the Kingdom of the Netherlands and the Government of the French Republic concerning the reprocessing in France of Dutch irradiated fuel elements, The Hague, 20 April 2012.

[33] Correspondence between the Government of the Kingdom of the Netherlands and the Government of the United Kingdom of Great Britain and Northern Ireland in respect of the possible return delivery of the remaining radioactive waste following reprocessing of irradiated reactor fuel, The Hague, 12 September 1978.

Part C – Process and implementation

Part C provides a vision on the process towards disposal. This refers to the issues of how we structure the decision-making process and how the public is involved (chapter 6). Action points from the programme and milestones in the process of achieving disposal and progress indicators for the national programme are also provided (chapter 7).

Chapter 6 – Vision on the process towards disposal

A decision on disposal is expected to be taken towards the year 2100. At present, it is not possible to predict what that decision will be, and what will then be the best method for managing radioactive waste. The drawing up of trend analyses in the meantime and the assessment of those analyses must ensure that the process towards disposal continues to progress. It is essential that society be involved in this process. In this chapter, the Cabinet offers its vision on the process towards disposal.

6.1 Process towards disposal

6.1.1 No decision at present

The Dutch policy on radioactive waste is stable. For more than thirty years, it has assumed the aboveground storage of the radioactive waste for a period of at least 100 years. Around 2130, a geological disposal will have been provided (see chapter 4.3). If an operational disposal facility must be working by 2130, the first steps towards selecting a location must be taken in 2100. This means that before that time, a decision will have to be taken on the long-term management of radioactive waste. This decision may mean that the process towards disposal will be started at that moment or that – because of technical and/or social uncertainties or because of the availability of other solutions – the process may be postponed until further notice (see also chapter 6.2).

It is not possible to predict what the best means of managing radioactive waste will be at the moment the decision is taken or what school of thought will prevail in society. Developments may take place which justify another choice than geological disposal of the radioactive waste on Dutch territory. Possibilities include technological developments or international cooperation in creating a disposal facility for radioactive waste.

If no change takes place in the current policy line in terms of timetable and disposal method, the process towards realisation of a national geological disposal facility will be implemented. It is important to remain flexible in order to be able to take up opportunities and possibilities for cooperation. Geological disposal, according to current thinking, is technically the safest and most sustainable management option for high level radioactive waste. Future generations must have the necessary resources, such as knowledge and funding, to be able to implement a disposal facility. At the same time, it is essential that the route towards geological disposal be not cast in stone, with definitive decisions as a result of which the necessary flexibility in the choice of management method for the long term is removed.

6.1.2 Trend analysis of developments

In order to be able to respond to developments in the field of disposal and to identify opportunities, it is necessary to continue to monitor developments in relation to the management of radioactive waste. This refers to developments in respect of:

- politics and administration.
  At present, in both domestic and foreign politics, the disposal of radioactive waste is a sensitive subject. There is not a single Member State currently willing to import radioactive waste from another Member State, for disposal. The Netherlands itself is responsible for its own radioactive waste, but cooperation in developing a disposal facility is not excluded. If possibilities do arise for cooperation, these must be investigated for applicability to the Dutch situation. Cooperation is already in place in respect of research (see also annex E.2.3).

- technology-science.
  To create a geological disposal facility (research) knowledge and experience will be needed. One of the most important requirements for a disposal facility is the safety of the installation for man and the environment and guaranteed security aspects. Sufficient knowledge and experience must be available among the generations processing the radioactive waste, taking decisions and actually implementing the disposal facility. One of the questions is whether we should now initiate research over many generations, or whether we should simply strengthen the knowledge and research basis at the moment that developments occur. Innovations in the field of waste management must also be monitored. If opportune, the focus of research in disposal could be shifted to new technology.
- society.
  In today's modern society, everyone is directly or indirectly involved in sectors that use radiation and generate radioactive waste. In that sense, the management of radioactive waste is something that affects us all. It is therefore of vital importance that everyone be given an opportunity to contribute ideas and take part in the discussion concerning the best solution for the radioactive waste. Actively involving the public at the right moments in implementing the programme is a key component of the route towards disposal (see chapter 6.2).
- spatial aspects and security.
  The underground environment plays an important role in solving numerous social issues: geological disposal of radioactive waste is certainly not the only function proposed for the deep underground environment. Attention should also be given to the spatial developments both above and belowground and security and contingency planning.

The monitoring of the relevant developments referred to above will be achieved by means of periodically preparing a trend analysis in relation to the disposal of radioactive waste. The outcomes of this trend analysis will then be assessed within a consultation group. The consultation group will consist of representatives of social, scientific and administrative organisations, and will be assembled in such a way that advice can be issued on all relevant developments. The consultation group will then issue advice as to whether there are grounds for initiating and/or intensifying particular programmes such as research and public participation. The consultation group should thereby take account of the phase of Dutch policy: as the year 2100 approaches, the national programme will have to be elaborated in further detail. The consultation group will also be required, on the basis of the trend analysis, to determine whether developments have taken place that make it necessary to adjust the programme.

The frequency of preparing a trend analysis will be matched to the frequency of reporting on the progress of the national programme to the European Commission: every three years, a summary trend analysis will be prepared. A more detailed trend analysis will be drawn up when the national programme is updated, once every ten years. This is more than sufficient to monitor the developments in respect of the disposal of radioactive waste. For the structure of the consultation group and the requirements for a trend analysis, refer to the relevant action point in chapter 7.1.2.

The Cabinet has identified agenda items for the consultation group for the next report to the European Commission. These points will offer the consultation group clearer direction and focus. The consultation group has been asked to focus attention on:

- identifying specific forms of participation
- financing of disposal and the related uncertainties
- potential suitable search areas for the disposal of radioactive waste that can be reserved, and identifying the necessary policy harmonisation, given other future functions of the (deep) underground environment at those sites.
- maintaining the necessary knowledge structure in the Netherlands

- the criteria for determining the period of retrievability of radioactive waste from disposal
- the possible policy implications of the results of OPERA.

The Cabinet will use the report from the consultation group on these points in reviewing the national programme in 2025.

6.1.3 Reversible decision making

The process towards disposal must in principle be reversible with a view to manageability[34]. This means that during the entire process of preparation, realisation and disposal of the waste, before each step is taken, consideration will have to be given to whether the step should be taken, or whether a step back should be taken in the process (see figure 6.1). At the end of the day, the only irreversible step will be closure of the disposal facility. Annex E.1.3 relates to the phases that make up the process of disposal.

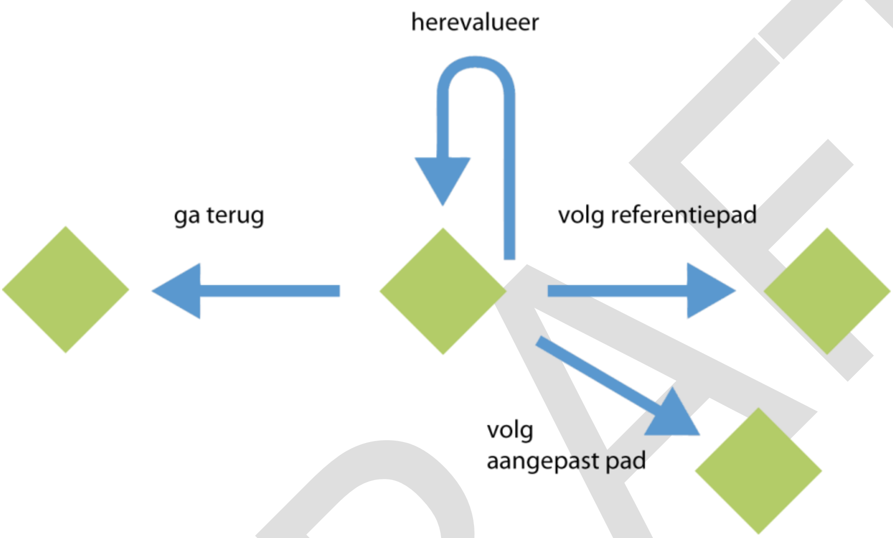

Figure 6.1 Reversibility of decisions (source: COVRA, based on figure from OECD/NEA).

Reversibility of decisions makes it possible to respond flexibly for example to:
- new technical information about the site and the design;
- new technological developments in respect of radioactive waste management (such as packaging, partition and transmutation)
- changes to social and political conditions and acceptance;
- changes to (interpretation of) statutory guidelines and possible changes to the basic standards;
- possibilities for international cooperation.

Thanks to the flexibility offered by a reversible process, it is possible to make optimum use of the available management options and design alternatives. The principle will always be: safe management of radioactive waste: now and in the future.

6.2 Public participation

This chapter discusses the purpose of participation, the parameters for a constructive participation programme and what this means for the Dutch situation.

Decision making on the management of radioactive waste for the long term is complex: it affects not only our generation but also future generations. In the future, if disposal is

[34] Parliamentary papers, session year 1992-1993, 23163, no.1.

to be achieved, the decision will have to be broadly supported. For that reason, society will have to be involved in time with the process of decision making on disposal. The purpose of participation in the decision making on disposal is that around the year 2100 or as much earlier as necessary, a broadly supported choice will be made in the Netherlands on the future method of managing radioactive waste. Participation is above all also important for establishing mutual trust, building bridges and being open to the ideas of others such as citizens, governments, social organisations, scientists and other stakeholders. For a subject such as radioactive waste and disposal, this is essential.

6.2.1 Research

The disposal of radioactive waste is a complex issue. Research relating to this national programme (see the report on public participation) has shown that the traditional means of decision making, based on the outcomes of scientific research, are insufficient for a subject such as disposal. Because participants in the decision-making process are dubious about the reliability of the knowledge available, the decision making could become bogged down. This has also been shown to be the case in this process in a number of countries (United States, Germany, United Kingdom), although in each of these countries other causes can be identified (such as political choices and general resistance to nuclear power).

Research accompanying this national programme has led to the formulation of a vision on public participation for the management of radioactive waste in the long term. Recommendations and parameters for a constructive participation programme have emerged (see the report on public participation):

- Participation is more than simply involving citizens. Governments, social organisations, industry and scientists must also be involved in the decisions on the long-term management of radioactive waste;
- For a constructive participation process, it is essential that the outcome of the decision-making process has not been determined in advance;
- Continuous investments must be made in creating and strengthening the basis of trust and the willingness for participation among government, citizens, scientists and other stakeholders;
- In the absence of actual decision making, for many citizens the urgency to participate is also lacking;
- The management of spent fuel and radioactive waste is an ambiguous policy issue. This issue can be divided into different sub issues, such as multinational disposal, management option and location choice. The relationship between nuclear power and radioactive waste also plays a role in the background. Participation must be initiated for each subject area;
- Participation is possible at different levels: from obtaining information through to joint decision making. For each subject area, the level of participation will have to be determined;
- A distinction must be made between different participants in the participation programme, such as citizens, governments, social organisations, industry, the implementer of the disposal and scientists. Each of these participants will have their own role in the decision-making process and the participation process;
- The results of research into the management of spent fuel and radioactive waste must as far as possible be made freely available, and these results should be presented accessibly and understandably.

If these recommendations are translated into the current situation, this means that there is no urgency at present for participation. There are developments that could represent a starting point for initiating participation. These are further elaborated in the rest of this chapter. The periodic trend analysis (see chapter 6.1.2) will also consider public participation.

6.2.2 Broader than citizens alone

Not only the residents of the Netherlands but also government authorities such as municipalities and provinces, government organisations such as water boards and social organisations must be able to participate. Local and provincial governments, for example, each have their own role in respect of spatial decision making, as do affected organisations for example in respect of the environment, sustainability and society. The waste management organisations and the scientists also have a role to play. Any decision on the long-term management of radioactive waste can only be taken if the subject is considered jointly by the whole of society, each element of society fulfils its role and everyone is confident in one another, so that at the end of the day the correct decision is taken on the long-term management of radioactive waste.

Experiences abroad have shown that an exclusively scientific approach is insufficient in order to arrive at a broadly supported policy on the long-term management of spent fuel and radioactive waste. Successful participation programmes have only been achieved in countries that invest intensively, over a long period of time, in involving local governments, citizens and social organisations in the decision making on the long-term management of spent fuel and radioactive waste. As long as no choice of location has been made, involvement will remain at the level of umbrella organisations such as VNG (municipalities), IPO (provinces) and the Union of Water Boards.

Furthermore, imposing a decision from above has proven relatively unsuccessful. Good cooperation and harmonisation between national and local governments is essential in order to arrive at a constructive decision-making process.

Possible decision making

At present, there is no talk of a decision on a location. If the current policy line is continued, a decision at the latest around the year 2100 will consist of the following possibilities:

A. The decision to start the process towards geological disposal;
B. Postponing this decision due to technical and/or social uncertainties (this choice effectively means extending the current situation of aboveground storage);
C. Opting for a newly developed technology, which is preferable to the other two options.

As a result, the outcome of the participation programme is not fixed. The end point, disposal, is fixed on the basis of current thinking, but there is sufficient space to determine when the programme towards actual realisation will be initiated. Furthermore, different decisions can be taken on specific subject areas. The current policy line rejects no realistic options. In other words, if an entirely new technology should become available in the future, that too could be selected.

6.2.3 No participation moment yet

Studies relating to this national programme reveal that as yet, it is not meaningful to initiate public participation in the discussion of disposal: the absence of an actual decision on the location means that at present the urgency to participate is also lacking, among many citizens (see the report on public participation).

It remains difficult to determine a future starting point for this participation. Technological and international developments make the timetable uncertain. It is possible that the closure of the nuclear power plant in Borssele will be a good moment for starting public participation in advance. The consultation group must remain alert to possible starting moments for participation. Participation will be a subject of the three-yearly trend analyses, see chapter 6.1. The consultation group itself will in fact be a form of public participation.

Participation in the future

The management of spent fuel and radioactive waste is a complex policy issue. This issue can be divided into a number of sub questions, such as multinational disposal, management option and choice of location. Participation in each sub area is an obvious possibility, and itself is possible at various levels: from obtaining information through to participating in the decision itself. The level of participation will have to be determined for each sub area. Within the ENGAGED project as part of the OPERA research programme, these issues will be considered in more detail. The design for the process of participation is one of the subjects for the consultation group for the next update of the national programme in 2025 (see action point chapter 7.1.2).

Consultation

In respect of the awarding of licences for the management of radioactive waste, there are of course a number of different consultation moments. During these consultation moments, everyone will be given an opportunity to present his or her opinion. This national programme is also available for consultaion.

Analysis of online debate

Internet and social media play an important role in society. To gain an insight into the international debate on radioactive waste, an analysis of online debate has been carried out (see the report on the analysis of online debate). This analysis reveals that at present, there is little online discussion of disposal in the Netherlands. In the current phase of the management of radioactive waste, disposal is indeed a long way away. It is therefore not yet meaningful to continuously monitor the online environment. At the moment that the process towards disposal comes closer to the choice of disposal method or choice of location, or if other factors lead to increased discussion, the monitoring of the online environment can be restarted (see action point chapter 7.1.2).

Chapter 7 – Implementation

**This chapter describes the action points in the national programme. These action points specify what has to be done when, in relation to the policy on radioactive waste.
The policy on radioactive waste has a long time horizon, of between several decades and more than a complete century. Within this time horizon, a number of milestones can be distinguished. The progress along the route to disposal can be clarified with the help of *performance indicators*.**

7.1 Action points

This is the first national programme in accordance with Directive 2011/70/Euratom. Every ten years, the policy on the management of radioactive waste will be updated in the national programme to be submitted to the European Commission. The action points in the national programme help to measure the progress of the process. Every three years the Netherlands reports to the European Commission on the implementation of the Directive. The reporting moments will also be used, where necessary, to revise the action points. In this way, the Cabinet will work towards disposal in a phased approach.

The action points can be divided into action points relating to regular policy on radioactive waste and action points relating to the progress of the national programme.

Action points from regular policy on radioactive waste:

- The transfer of historical radioactive waste from Petten to COVRA
- Release thresholds for materials, buildings and sites
- Guide and licencing regulations for dismantling non-nuclear applications
- Decay storage
- Imposing rules on import and export, storage and disposal of radioactive waste from abroad
- Financial aspects in the termination plan of a facility
- Investigating the consequences of new European basic standards on the volume of radioactive waste

For an elaboration, see chapter 7.1.1.

Action points in the process of the national programme:

- Environmental impact assessment
- Reporting on implementation of the national programme
- Updating the national programme on radioactive waste
- Drawing up a waste inventory
- Appointing a consultation group
- Analysis of online debate

For an elaboration see chapter 7.1.2.

7.1.1 Action points from regular policy on radioactive waste

Transfer of historical radioactive waste from Petten to COVRA (see chapter 3.4.1)

Between 1985 and 1992, COVRA managed conditioned LMRA and a small volume of HRA waste at the ECN site in Petten. This radioactive waste was produced by the Dutch nuclear installations. During this period, in its Waste Storage Facility (WSF), ECN managed the radioactive waste generated by the research reactors (HFR and LFR). The approx. 1700 drums were due to be managed at this location, for many years. Because policy has specified since 1984 that any radioactive waste produced in the Netherlands should be collected, processed and centrally stored by COVRA, the waste from Petten (the so-called 'historical waste') also needs to be moved to the COVRA location. However, the drums from the WSF do not meet the (packaging) requirements imposed by COVRA for long-term storage. The waste from Petten was produced in a period when a whole range of materials with different radiation levels were stored together. In addition, the transport requirements have been tightened up over the years. Sorting, repackaging and conditioning in line with current requirements must therefore first be carried out.

There are no facilities for the conditioning of this historical waste in the Netherlands. For this purpose, part of the waste will be transported to Belgium, to be processed at the company Belgoprocess. Following conditioning the end product will be transported to COVRA, for storage.

Action: transport of historical waste to COVRA
Implementation: NRG, approval by ANVS
Planning: finalized by 31 December 2022, further assessment 2017

Underground Structural Vision (see chapter 4.1)

In the Underground Structural Vision (STRONG), consideration is given to the use of the environment below the Netherlands through to the year 2040. Geological disposal of radioactive waste is not included in this vision, because it is not planned until later, well beyond the year 2040.

Action: determining whether geological disposal of radioactive waste should be included in the Underground Structural Vision
Implementation: ANVS and Underground Structural Vision
Planning: for the next report (23 August 2018)

Release thresholds for materials, buildings and sites (see chapter 4.2.2)

On the basis of the *Nuclear Installations, Fissionable Materials and Ores Decree* (Bkse), the licence holder of a nuclear installation is required to immediately initiate dismantling, following cessation of the business activity. The site must be remediated to 'green field' status. The creation of a 'green field' means that following completion of dismantling, at the location of the nuclear facility there must be no further restriction for any future use, in so far as such restrictions are the consequence of the presence of the facility (art. 30a, paragraph one, Bkse). These restrictions relate both to radiological and non-radiological aspects. (The rule of immediate dismantling was not yet in place in 2005 when the decision was taken to postpone dismantling of the nuclear power plant in Dodewaard, to 2045).

If the activity level and the activity concentration are equal to or below the release thresholds, the material may be released in accordance with the *Radiation Protection Decree*. Release is unconditional; in other words, you can do anything with the material, and no conditions are imposed on the basis of the Nuclear Energy Act. The release of material and its subsequent reuse will prevent the necessity of incorrectly storing the material as radioactive waste.

A draft practical guide is developed that provides answers to questions about when materials, buildings or sites can be released, and how this can be demonstrated.

Action: Completion and publication of a guide for the release of materials, buildings and sites following dismantling of a nuclear installation

Implementation: ANVS
Planning: finalized by 31 December 2017

Guide and licensing regulations for the dismantling of non-nuclear applications (see chapter 4.2.2)

On the basis of the *Radiation Protection Decree*, and on the basis of licences issued, the use of radioactive sources must be brought to an end. The licence holder must guarantee the safety of the workforce and members of the public during dismantling, and during the operational phase.

The licence holders of nuclear installations are required to submit updated dismantling plans to the competent authority, every five years, in accordance with the law. However, this obligation does not apply to licence holders for non-nuclear applications. For this latter group of licence holders, licence regulations are developed as standard for the drawing up and periodic updating of termination plans for non-nuclear applications, whenever radioactive sources are regularly used. For this target group, a guide will also be prepared, explaining the process of termination and drawing up of the termination plan.

Action: Development of guide and standard licencing regulations for termination of non-nuclear applications
Implementation: ANVS
Planning: finalized by 31 December 2017

Decay storage (see chapter 4.2.3)

In a decay store, materials that need more than two years to decay to below the release thresholds, can be safely stored. For that reason, it was decided in 2014 that materials originating from the dismantling of large permanent installations (such as cyclotrons) are allowed to be stored unprocessed for a maximum period of 25 years at COVRA, if within 25 years the activity of the waste decays to below the current release thresholds. After that time, the materials can be reused as raw materials. The precondition for the reuse of decayed radioactive waste must be that it represents no risk whatsoever for the user.

Certain materials need longer to decay to below the release thresholds. There may also be other material than dismantling material that is suitable for placement in a decay store to allow it to decay below the release thresholds. Investigating the possibility of expanding the decay storage for these materials is an action point in this programme.

Action: Investigating the expansion of decay storage
Implementation: ANVS and COVRA
Planning: finalized by 31 December 2017

Imposing rules on the import, export, storage and disposal of radioactive waste from abroad (see chapter 4.3.2)

In addition to the licencing obligations, there are no statutory limitations on the importing of radioactive (waste) substances from abroad, for storage and disposal in the Netherlands. The current storage capacity at COVRA has been dimensioned for the expected volume of Dutch radioactive waste. To make sure that there is no uncontrolled increase in the volume of radioactive waste, the possibility and desirability will be investigated of introducing rules on the import of radioactive waste from abroad for storage and/or disposal in the Netherlands. A number of European countries including France, Finland, Croatia, Switzerland and Sweden have already included similar conditions in their legislation and regulations[35]. The Netherlands intends to join in, in order to counter in principle unintended import. The necessary transport must comply with the international safety requirements.

Action: Investigating the possibility for laying down rules for storage and disposal of radioactive waste
Implementation: ANVS
Planning: finalized by 31 December 2017

Financial aspects in termination plans (see chapter 4.5.1)

The bankruptcy of Thermphos made it clear that the costs of termination at businesses handling radioactive substances can be considerable. There are approximately 30 businesses and institutions with an existing Nuclear Energy Act licence, where the costs of company termination are estimated as relatively high. This includes companies involved in the processing of raw materials, companies in the oil and gas production sector and the processing of residual products from oil and gas production, and companies operating cyclotrons/particle accelerators. The introduction of a termination plan is to be investigated. This will have to include the financial aspects of termination.

Action: Investigation among affected companies into the introduction of a termination plan with attention for financial aspects.
Implementation: ANVS
Planning: finalized by 31 December 2017

Investigating the consequences of new European basic standards on the volume of radioactive waste

In the new European basic standards (BSS, Directive 2013/59/Euratom), the release and exemption thresholds have been updated. This updating process could have consequences for the volume of radioactive waste (in particular NORM waste). This may have consequences for the radioactive waste policy.

Action: Investigating the consequences of the implementation of the BSS on the volume of radioactive waste and radioactive waste policy.
Implementation: ANVS
Planning: finalized by 31 December 2020

7.1.2 Action points from the process for the national programme

Environmental Impact Assessment (see chapter 2.1)

In the process towards disposal, the environmental effects that could result from disposal must be fully taken into account in the decision-making process. With this national programme, an initial study was undertaken that provides an outline description of the consequences of various disposal concepts. This study is the first in a whole series. As the concept of disposal becomes more concrete, more and more detailed Environmental Impact Assessment reports will be drawn up.

Action: Definition of criteria for start of first Environmental Impact Assessment
Implementation: ANVS
Planning: finalized by 31 December 2030

Reporting on implementation of the national programme (see chapter 2.2)

[35] Parliamentary papers, session year 2012-2013, 25 422, no. 105.

Every three years a report must be submitted to the European Commission on implementation of the national programme. For the first time in 2016.

Action: Reporting on implementation of the national programme
Implementation: ANVS
Planning: 2016, and then every 3 years

Updating of the national programme on radioactive waste (see chapter 2.2)

On the basis of the Directive, every 10 years, the Netherlands is required to update the national programme. If the need arises, the national programme must be updated earlier.

Action: Updating of national programme
Implementation: ANVS and the Minister of Infrastructure and the Environment
Planning: finalized by 23 August 2025, and then every 10 years

Drawing up waste inventory (see chapters 3.4.3 and 3.5)

On the basis of the Directive, every 3 years, the Netherlands must report on the progress of the national programme. A waste inventory should be part of this report. The waste inventory provides a picture of the volume of LMRA, HRA and NORM waste in storage at COVRA. The waste inventory also provides a forecast of the volume expected by 2130; the year in which a disposal facility is expected to become operational.

Action: Drawing up waste inventory
Implementation: COVRA on behalf of ANVS
Planning: for the next report (23 August 2018) and then every three years.

Appointing consultation group (see chapter 6.1)

The long period of aboveground storage in the Netherlands results in a series of challenges. One of those challenges is that the progress of the programme must be guaranteed. In addition, there must be a flexible response to the planned policy if developments or new insights give grounds therefor. A consultation group can guarantee the continuity of these tasks and ensure that a successful policy on radioactive waste policy is guaranteed for the longer term.

Action: The establishment of a consultation group and a system in which implementation of a trend analysis is laid down. To bring this about, a clear concrete assignment description must be provided for the consultation group, and the requirements for the composition of the consultation group must be drawn up. The agenda of the consultation group is described in chapter 6.1.
Implementation: ANVS, Ministry of Infrastructure and Environment
Planning: finalized by 31 December 2016

Analysis of online debate (see chapter 6.2)

Internet and social media play an important role in today's society. Research in the framework of this national programme revealed that in 2014, there was little online discussion in the Netherlands concerning disposal (see report of the analysis of online debate). In the current phase of the management of radioactive waste, disposal is still a long way away. As the process towards disposal comes closer to the choice of disposal method and choice of location, the monitoring of the online environment can once again be started.

Action: Periodic analysis of online debate
Implementation: ANVS and consultation group
Planning: start and frequency to be determined by consultation group

7.2 Milestones

Closure of the Borssele nuclear power plant

The closure of the only nuclear power plant in the Netherlands is planned for 2033. Borssele is the largest source of high level radioactive waste in the Netherlands.

What: closure of Borssele nuclear power plant
When: finalized by at the latest 31 December 2033

Receipt of last produced spent fuel from the Borssele nuclear power plant

The closure of the only nuclear power plant in the Netherlands is planned for 2033. At the latest by 2052, the last waste from the reprocessing of the spent fuel from this power plant will be returned to the Netherlands.

What: Receipt of last reprocessed waste from the Borssele nuclear power plant from the reprocessing plant La Hague in France
When: finalized by at the latest 31 December 2052

End of period aboveground storage

The buildings at COVRA are suitable for safely storing the radioactive waste for the next 100 years, and thanks to periodic maintenance the lifecycle of these buildings can be extended. This storage period also provides time for the waste to lose a large part of its heat production through natural decay. The period of storage will also be used for saving up waste and for saving the necessary financial resources for disposal.

After the period of aboveground storage, a decision will have to be taken on the next stage. This process will have to be preceded by public participation, scientific supporting argument and political discussion. For the process to be a success, when the time comes, these processes will have to be initiated.

What: Decision on disposal
When: COVRA will provide for the storage of all radioactive waste for at least 100 years. If the disposal facility has to be operational by around 2130, at least by around 2100, a decision on this facility will have to be taken.

7.3 Performance indicators

Performance indicators are indicators of the progress of the national programme. Reports are issued in the three-yearly reporting cycle on the national programme, in respect of the following performance indicators:

- *Financing* – Amount available for disposal is sufficient for preparation, construction, operation and closure of the disposal facility;
- *Status action points* – Timely implementation of the action points from the action list;
- *COVRA capacity* – Volume of space available is sufficient for the expected volume of Dutch radioactive waste.

Annexes

Annex A – Terms, definitions and abbreviations

Waste inventory	Study by COVRA in which an inventory is produced of the volume of radioactive waste which (1) is currently present in the Netherlands and (2) is expected in the future. This supporting study is available at www.anvs.nl under the heading radioactive waste
ALARA	*As Low As Reasonably Achievable*
Management of radioactive waste substances	All activities relating to the handling, pre-treatment, processing, conditioning, storage or disposal of radioactive waste substances, with the exception of transport outside the facility site
Management of spent fuel	All activities relating to the handling, pre-treatment, processing, conditioning, storage or disposal of spent fuel, with the exception of transport outside the facility site
Bkse	Nuclear Installations, Fissionable Materials and Ores Decree
Bs	Radiation Protection Decree
Bvser	Transport of Fissionable Materials, Ores and Radioactive Substances Decree
COG	Container Storage Building
NCEA (Commissie m.e.r)	Netherlands Commission for Environmental Assessment
Conventional waste	Waste substances as intended in the Environmental Protection Act (or non-radioactive waste)
COVRA	Central Organisation For Radioactive Waste
Cyclotron	A circular particle accelerator, generally employed for scientific research for the production of medical radio-isotopes
Dose	Absorbed energy per mass unit (unit: Gray, Gy)
Equivalent dose	Product of the dose and radiation weighting factor. The radiation weighting factor takes account of the relative biological effect of the radiation type (unit: Sievert, Sv)
Disposal facility	The facility in which radioactive waste substances or spent fuel are placed without the intention of retrieval.
HABOG	High level radioactive Waste Treatment and Storage Building
Half-life ($t_{1/2}$)	This is the time required to reduce the number of radioactive atoms by half
HFR	High Flux Reactor
HRA	High level radioactive waste
IAEA	International Atomic Energy Agency
IenM	Dutch Ministry of Infrastructure and the Environment
Ionising radiation	1. Charged particles (electrons, protons, atomic nuclei, etc.) with sufficient kinetic energy to cause ionisation through collisions 2. Uncharged particles (neutrons, photons, etc.) that can

	release the charged particles referred to above, or can initiate transformations of atomic nuclei.
Isotopes	Atoms of the same element (atomic number) with the same chemical properties, but with a different number of neutrons in the nucleus (mass number)
Kew	Nuclear Energy Act
LFR	Low Flux Reactor
LMRA	Low level and Intermediate level Radioactive Waste
LOG	Low level Radioactive Waste Storage Building
MOX	Mixed oxide
National programme	The national programme for the responsible and safe management of spent fuel and radioactive waste as intended in article 20h of the *Radiation Protection Decree* and article 40a of the *Nuclear Installations, Fissionable Materials and Ores Decree*
NORM	Naturally Occurring Radioactive Material
NRG	Nuclear Research & consultancy Group
OPERA	Research Programme Disposal Radioactive Waste (www.covra.nl/eindberging/introductie)
Storage	The facility in which radioactive waste substances or spent fuel are managed with the intention of retrieving the waste substances or spent fuel
Reprocessing	Series of chemical processes whereby the remaining fission material is retrieved from spent fuel
Partition and transmutation	Technique according to which radionuclides with a long life are separated and converted into radionuclides with a shorter life
Radioactivity	The phenomenon according to which unstable radionuclides spontaneously emit radiation particles and/or high-energy electromagnetic radiation at the moment of transition to a more stable form
Radionuclides	See isotopes
Radioactive waste	(Bs, art. 38) A radioactive substance may be designated as radioactive waste by our Minister or the operator if no use or product or material re-use is foreseen for that material by the Minister or the operator and there is no question of discharging the substance (Bs, art. 38)
Radioactive decay	Natural, spontaneous process whereby an unstable nuclide changes to another nuclide, through the emission of radiation
Radioactive substances	Materials emitting ionising radiation
Report on International research	Report prepared by NRG in which the status is described of international research into disposal. This supporting study is available at www.anvs.nl under the heading radioactive waste
Report of Online environment analysis	Report prepared by EMMA Communicatie in response to an online environment analysis of the discussion concerning radioactive waste and disposal. This supporting study is available at www.anvs.nl under the heading radioactive waste

Report on Public participation	Study by the Rathenau Institute in which a vision and strategy is given on public participation in respect of disposal. This supporting study is available at www.anvs.nl under the heading radioactive waste
Directive 2011/70/Euratom	Directive 2011/70/Euratom of the European Council dated 19 July 2011 on the establishment of a community framework for the responsible and safe management of spent fuel and radioactive waste
RID	Reactor Institute Delft
Fission materials	Substances containing at least a percentage of uranium, plutonium or thorium as specified by a government decree. This percentage is respectively one tenth, one tenth and three, calculated according to weight
Radiation	See ionising radiation
Spent fuel	Fission material that has been irradiated and permanently removed from a reactor core
Initial study	Study by Arcadis investigating the options for the long-term management of radioactive waste. This supporting study is available at www.anvs.nl under the heading radioactive waste
Enriched uranium	Uranium with a higher mass percentage of uranium-235 than natural uranium
VOG	Depleted uranium Storage Building
Release	When the activity of the waste falls below a specified threshold, or falls below that threshold as a result of decay, it is no longer radioactive waste. It can then be safely released for reuse or delivery to a conventional waste processor. The release thresholds are laid down in law, and differ for each radionuclide
Wm	Environmental Management Act
WSF	Waste Storage Facility
ZELA	Very Low Level Radioactive Waste

Annex B – Introduction to radiation

This annex is an introduction to radiation and the risks and sources of radiation. Radioactive waste emits radiation. During the period in which the waste emits radiation, it must be safely stored.

B.1 Radiation

Radioactivity is a natural phenomenon according to which atoms in an unstable condition decay into stable atoms over the course of time. During this process, energy is released in the form of particles or electromagnetic waves. This is known as radiation. All materials occurring in nature contain radioactive atoms to a greater or lesser degree. Radioactive atoms are also known as radionuclides.

Radiation can be divided into ionising and non-ionising radiation. Non-ionising radiation consists of electromagnetic waves with a level of energy that is too low to release electrons from atoms. Ionising radiation does have sufficient energy to release electrons from atoms (in other words to ionise) and can as a consequence potentially cause damage to living tissue and materials. Whenever the term radioactivity is used, it refers to ionising radiation.

Ionising radiation can be divided into:

- Alpha radiation: Alpha particles are relatively large and as a consequence easier to stop. A sheet of paper offers sufficient protection. Alpha particles are however highly ionising and as a result cause considerable damage in the event of internal contamination.
- Bèta radiation: Bèta particles are smaller and lighter than alpha particles. A few millimetres of aluminium or a few decimetres of water or plastic are generally sufficient protection against this type of radiation;
- Gamma radiation: electromagnetic radiation with less ionising capacity than alpha or bèta radiation, but more difficult to shield. Adequate shielding requires metal such as lead, or concrete. The thickness will depend on the type of gamma radiation.

Figure B.1 provides a diagrammatic representation of the above.

B.2 Applications

Ionising radiation has many applications. In a nuclear reactor, it is used to generate electricity while in research reactors ionising radiation is used for scientific research for example into new materials and medicines, but also into more modern solar cells or batteries. The research reactor in Petten produces medical radio-isotopes for radiotherapy and diagnostic purposes.

As well as applications in the nuclear sector, ionising radiation is used and found in the Netherlands at a wide variety of locations. Key examples are:

- Practices using appliances that emit ionising radiation in medical and veterinary institutions. In total there are several tens of thousands of devices that are used for therapy and diagnostic purposes;
- The production and preparation of medical radio-isotopes using cyclotrons and a number of hotcells in various institutions. These radio-isotopes are used for therapy and diagnostics;

- Practices with radioactive substances for diagnostic and therapeutic purposes in medical and veterinary institutions;
- Practices involving devices for scientific research, for example the use of particle accelerators in fundamental research;
- Practices involving sources in industry, for example for non-destructive testing of objects for product process, and research institutions;
- A variety of consumables and consumer articles containing radioactive substances. Examples are luminescent sources and thorium-bearing lamps.

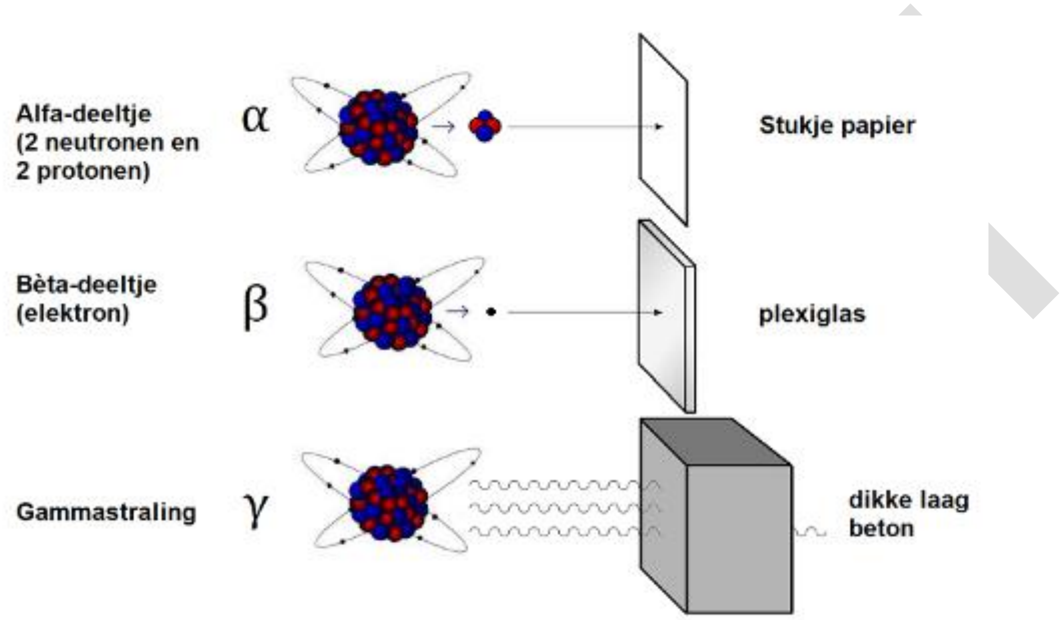

Figure B.1 Types of radiation and the screening method (source: http://www.sciencespace.nl/).

B.3 Risks

Radiation can damage the DNA in the body's cells for example by causing fractures in the DNA. However, these cells are equipped with a whole range of mechanisms for repairing such DNA damage. Every day, in every cell in the body, much damage occurs to the DNA through normal biological processes and environmental factors. In practically all cases, this damage has no consequences for health because such DNA damage can be repaired. However, DNA damage that cannot or cannot be successfully repaired can eventually lead to cancer. The risk of the occurrence of cancer due to radiation damage to the DNA increases as the dose rises.

With a very high dose of radiation, damage to health occurs immediately. This is because not only the DNA is damaged but at the same time many of the body's cells are killed. This effect is used in the radiation treatment of fast-dividing tumours. The effects can be temporary and local, such as reddening of the skin following the irradiation of cancer patients. At higher doses, the consequences can be very serious and even fatal, because then not only bone marrow and the intestines, but also the central nervous system could be damaged by radiation.

Radiation protection

Although it is impossible to fully avoid exposure to radiation, unnecessary risks can be limited. Protection against radiation is possible by:

- Limiting the amount of time to which people are exposed to a source;
- Maintaining a distance from the radiation source;
- Enclosing the radiation source in a suitable packaging;
- Shielding of the radiation source with the most suitable material such as lead or concrete.

The Sievert (Sv) is the unit for the equivalent dose of ionising radiation to which a person is exposed in a given period. This unit takes account of the type of radiation and the distance to the source, etc. To gain an impression of the dose that a human can be exposed to in daily life, a number of examples and information about radiation are provided in figure B.2.

- Eating a banana: 0.0001 mSv (1)
- Chest X-ray: 0.05 mSv (2)
- 10-hour intercontinental flight: 0.03 mSv (2)
- Legally permitted additional radiation dose for the population (above background radiation): 1 mSv per year (3)
- Average background radiation absorbed in the Netherlands: 2.5 mSv per year (4)
- CT scan: 10 mSv (2)
- Permitted additional radiation dose radiation workers in NL: 20 mSv per year (4)
- One-off dose whereby risk of death is 50%: 4500 mSv at once (total body radiation)

Sources: (1) Calculated, (2) UNSCEAR, (3) Radiation Protection Decree, with the exception of medical applications, (4) RIVM

Figure B.2 Information about radiation doses

Figure B.3 shows the average radiation dose in the Netherlands before 2011. On average, a person in the Netherlands receives 2.5 mSv per year: individually this may be lower or higher. In the event of medical exposure, only the contribution from diagnostic studies is included and not the contribution from medical therapy (radiation treatment of cancer).

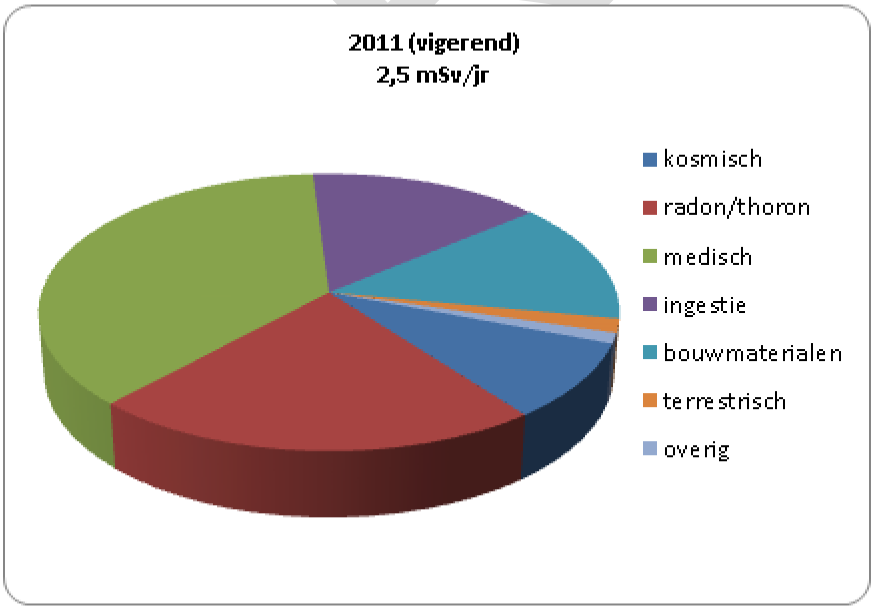

Figure B.3 Average received radiation dose in the Netherland (source: RIVM).

B.4 Radiation sources

Natural background radiation

Radionuclides occur everywhere in nature, in the air, water, soil and in plants. As a result everyone is continuously exposed to radiation: through natural radioactivity in the materials around us, but also for example by cosmic radiation from space. Rocks with natural radionuclides for example, may be used in construction materials as a result of which radiation levels indoors can rise. Radiation from these natural radiation sources is also known as background radiation. One cause of background radiation is radioactive uranium and its decay products. These occur in different soil types. Areas on earth with much uranium in the soil therefore have higher background radiation levels than areas with little uranium. Due to the favourable soil conditions in the Netherlands, the natural background radiation level from the soil is many times lower than in the surrounding countries. Granite, for example emits far more radiation than peaty soil.

Artificial radiation sources

There is also radiation that originates from manmade applications. The most important of these applications are diagnostic and therapeutic medical treatments such as making a CT scan or an X-ray photograph, treatment with medical isotopes and the radiation treatment of tumours. To a limited extent, people are also exposed to radiation from industry. As concerns the effect on people there is no distinction between natural or artificial radiation sources: only the level of the dose is relevant.

Annex C – Competent authority

This annex describes the competent authority for nuclear safety and radiation protection.

The Authority for Nuclear Safety and Radiation Protection (ANVS)[36] is the competent regulatory authority in respect of nuclear safety and radiation protection. On 1 January 2015, the ANVS was initiated as a temporary working organisation. Once the necessary legislation is adopted and becomes effective (planned on 1 January 2016), the ANVS will become an independent non-departmental public body (ZBO). The Minister of Infrastructure and the Environment bears ministerial responsibility for the ANVS.

The board of the non-departmental public body consists of 2 directors, supported by a staff of 120-150 people.

The following tasks (among others) have been entrusted to the ANVS for the fields of nuclear safety and radiation protection (including radioactive waste):

- preparation of legislation and regulations and policy (including this programme);
- issuing licences and the accompanying assessments and evaluation;
- supervision and enforcement; informing interested parties and the public;
- participation in the activities of international organisations;
- maintaining relations with comparable foreign authorities and national and international organisations;
- supporting national organisations through the provision of knowledge;
- carrying out research in support of the implementation of its tasks.

For the international orientation of the ANVS and the organisations that provide support, see the National policy on radiation protection and nuclear safety[37].

[36] www.anvs.nl

[37] National policy on radiation protection and nuclear policy, Annex to Parliamentary papers, session year 2014-2015, 25 422, no. 113.

Annex D – COVRA

This annex describes the current approach to managing radioactive waste by the Central Organisation for Radioactive Waste (COVRA).

D.1 Waste management organisation COVRA

The Central Organisation For Radioactive Waste (COVRA) was established in 1982 at the initiative of the Dutch government. COVRA was temporarily based in Petten, and since the end of the nineteen eighties has been relocated in Nieuwdorp (Municipality of Borsele, Zeeland). As the only approved organisation in the Netherlands, COVRA is responsible for the implementation of the radioactive waste policy and is responsible for the collection, processing and storage and eventual disposal of radioactive waste and spent fuel. The mission of COVRA is to ensure the safe storage of radioactive waste in the Netherlands until the time radioactivity of the material no longer plays a role, and a permanently safe situation has been achieved. Figure D.1 is a photograph of the overall COVRA site.

Figure D.1 COVRA site (situation beyond 2010).

COVRA is a private company, all shares of which have been held by the Kingdom of the Netherlands, since 2002. All operators in the Netherlands that have access to radioactive material are required on the basis of regulations (Bs, article 38) to tender their radioactive waste to COVRA, as soon as reasonably possible. Because COVRA is responsible for various different elements of the waste management chain, right at the beginning of the waste management chain, account can be taken of the requirements imposed on the storage and disposal of radioactive waste. Figure D.2 is a diagrammatic representation of the management chain for radioactive waste and the responsibility of COVRA within that chain.

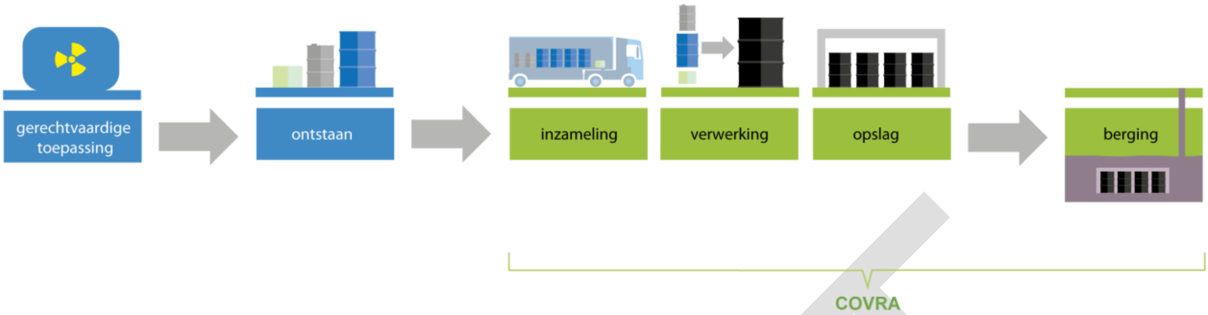

Figure D.2 Responsibility of COVRA in the management chain for radioactive waste (source: COVRA).

As part of its responsibilities, COVRA coordinates the OPERA (Research programme into the Disposal of Radioactive Waste, 2011-2016) research programme, the aim of which is to investigate how safe long-term storage of radioactive waste can be achieved in the Netherlands.

By placing all stages of the management of radioactive waste with a single organisation, COVRA, knowledge in this area is as far as possible combined. This guarantees the continuity of this knowledge throughout the period of aboveground storage. The ANVS supervises the safety and management of radioactive waste. The legal status of ANVS as a knowledge-intensive authority is a further guarantee thereof.

D.2 High level radioactive waste

High level radioactive waste (HRA) at COVRA is stored in the High level radioactive Waste Treatment and Storage Building (HABOG). This building was commissioned in 2003 and as far as possible equipped for passive safety. It is resistant to all types of extreme external influences such as tornados, gas cloud explosions, earthquakes, flooding and aircraft accidents. The waste is constantly monitored by measurements and checks.

A stress test[38] was carried out on the HABOG, in 2013. In a stress test report, a description is given of how a nuclear installation reacts to various extreme occurrences (such as earthquakes and flooding), accident management and the loss of electrical power supply and heat discharge facilities. The report also describes any potential improvement measures for improving the safety margins of the installation in the event of extreme occurrences.

On the basis of the stress test report, it can be concluded that there are no indications that the HABOG does not comply with the requirements of the current licence. The HABOG is safe. The HABOG also offers safety margins in respect of the technical and organisational requirements with which the installation is currently required to comply by law.

38 Parliamentary papers, session year 2013-2014, 32 645, no. 56.

Figure D.3 The HABOG – from outside

At the end of 2013, COVRA submitted a request to expand the storage capacity for HRA in the HABOG, and to optimise the layout of the site facility for LMRA. The licence was issued at the start of 2015. An appeal was launched against the licence. Following the judgement by the Council of State in response to this appeal, the licence will or will not be made irrevocable.

HRA is stored in special containers. These containers are placed in sealed vertical tubes, filled with inert gas. To discharge the heat produced by HRA, the HABOG has a passive cooling system. Cool outside air flows past the tubes containing waste, and the air heated by the waste is then returned outside. Because the waste is shielded from the environment, the passing air is not contaminated with radioactivity.

Just like all other COVRA buildings, the HABOG is a building according to modular design, whereby at the moment of construction, account was taken of expansion. The 1.7 metre-thick concrete walls shield against radiation and protect the staff and the environment. As a result, maintenance, repairs or even replacement of the building can be carried out in an environment free from radiation. The building was designed for a useful life of at least 100 years, and, when subjected to inspection and maintenance, can in principle be used for a longer period.

Figure D.4 The HABOG – inside.

Spent fuel must be safely managed until the level of natural activity of uranium has once again been reached. The spent fuel rods from the research reactors will take about a quarter of a million years to decay to this level. During the reprocessing of the spent fuel rods from the nuclear power reactor, the plutonium is removed. As a result, this waste no longer takes a quarter of a million years but approximately ten thousand years to decay.

Part of the HRA emits heat. This is above all due to the decay of the shorter-lived radionuclides. During the period of aboveground storage, the amount of heat produced becomes ever smaller. A lower level of heat emission makes it easier to handle and store the HRA.

D.3 Low level and intermediate level radioactive waste

Whenever low level and intermediate level radioactive waste (LMRA) arrive at COVRA, the waste is conditioned in the waste processing building. It is processed to the smallest possible volume (volume reduction) and placed in drums that are subsequently filled with concrete (conditioning). The concrete has two functions: it immobilises the waste and provides shielding against the radiation. In the event of waste with a slightly higher level of activity, the waste and concrete-filled drums are placed in an additional concrete shell. This shell provides additional protection against radioactivity. The quality of the concrete is important. COVRA has a quality certificate for its own concrete production.

The drums are numbered, so it is at all times possible to trace the precise content. These drums are then stacked in rows in the Low level and intermediate level Radioactive Waste Storage Building (LOG), so that the drums can be carefully inspected.

Figure D.5 Low level and intermediate level radioactive waste stored in the LOG.

Figure D.6 The LOG – the outside.

D.4 NORM

A separate class of waste is NORM waste (Naturally Occurring Radioactive Material). This is waste in which the natural radioactivity has been raised by industrial processes: for example certain types of industrial waste such as depleted uranium or waste from the phosphate industry. The part of the depleted uranium produced at the uranium enrichment plant operated by URENCO, and identified as waste, is converted in France into solid uranium oxide, and stored at COVRA in standardised 3m^3 containers. These containers are stored in the Depleted uranium Storage Building (VOG).

Figure D.7 Depleted uranium stored in the VOG.

Waste from the phosphate industry is stored in large freight containers in the Container Storage Building (COG). The proportion of the waste in the COG that has decayed to below the release threshold is no longer radioactive waste. It can then be disposed of as conventional waste.

Figure D.8 Calcium calcinate stored in the COG.

Annex E – Disposal

Following a period of aboveground storage at COVRA, the intended plan is the geological disposal of radioactive waste. This annex describes a number of aspects relating to disposal, such as monitoring, knowledge assurance and reversible decision making. Research experience in the Netherlands and abroad is also considered, together with a description of a number of international collaborations.

E.1 Aspects relating to disposal

In the case of disposal, monitoring and knowledge assurance are also important. These aspects relate to different moments in the process of realising a disposal facility.

E.1.1 Monitoring

The storage of radioactive waste in a storage facility like COVRA requires active management and monitoring of the waste, the facility and the environment, to ensure that the waste is and remains stored in a safe and controlled manner. For the disposal of radioactive waste in a geological disposal facility, to some extent this situation changes. Both the packaging of the radioactive waste in special containers and the host rock in which the disposal facility is built provide isolation and protection of the radioactive waste. The correct choice of packaging and host rock will delay the release of radionuclides.

During the lifecycle (realisation, operation and phased closure) of the disposal facility, monitoring provides information on the basis of which (in part) the decisions can be taken within the project. In other words, monitoring contributes to the confidence in the disposal facility, both for the operator, the public and the regulatory and supervisory authorities.

As long as the waste is retrievable from the disposal, it is essential that the circumstances in and around the disposal facility will be monitored. After all, if there are any uncertainties concerning the circumstances of the radioactive waste and the surroundings, practical retrievability cannot be guaranteed. Once the disposal facility is closed (whether or not in phases), this fact represents challenges for the continuation of monitoring. A passive safety system relies on the fact that there is an impenetrable stable geological layer around the disposal facility. When for example cables from a monitoring device in the disposal facility travel through to the surface, it is possible that this represents a threat to the impenetrability of the layer, and hence the enclosure of the radioactive waste. International research is underway into the monitoring of geological disposal facilities. These studies are for example examining the precise purpose of a monitoring strategy, and what monitoring methods have most effect, without making the disposal facility susceptible to external influences.

E.1.2 Knowledge assurance

The process towards the realisation of a disposal facility stretches over several generations. In that process, it is essential that knowledge be assured. This is a multifaceted issue. Figure E.1 is a diagrammatic representation.

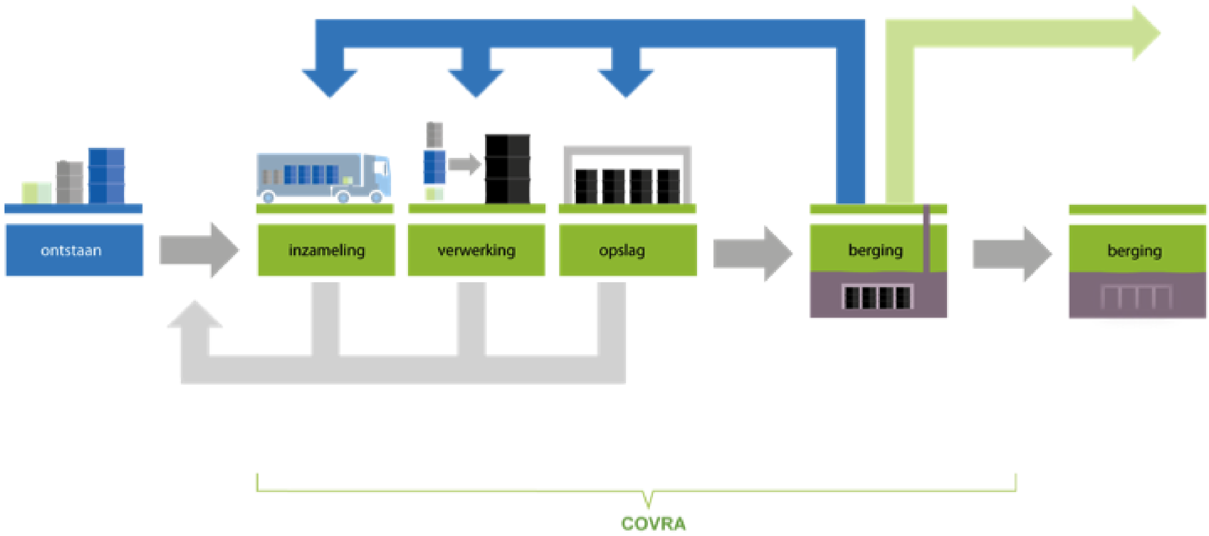

Figure E.1 Facets of knowledge assurance for disposal in the management chain for radioactive waste.

The following points must be considered:

- *Knowledge of the properties of the waste (knowledge for disposal, grey arrows)*

  During the period of aboveground storage, COVRA is responsible for the administration of and assuring the knowledge relating to the waste stored at the location. This is not only important for the future when the waste is placed in the disposal facility, but is also an important aspect of safe day-to-day operations.

  On the basis of the properties of the waste (for example precisely which materials are stored in which containers, the chemical structure, the activity of the material and the amount of radiation being emitted by the waste, but also about the conditioning and packaging methods), it is possible in the future to make a sound choice on the future management method for the various types of waste.

- *Technical and socioeconomic knowledge (knowledge about disposal, blue arrows)*

  Technical substantive knowledge in respect of radioactive waste management is acquired through research, on both a national and international scale. Research has been underway in the Netherlands for dozens of years into the safe disposal of radioactive waste (see annex E.2). Part C deals in greater detail with the process towards disposal.

  Not only the passing on of knowledge to future generations is important. Equally, it is now already important to have knowledge of the design of a future disposal facility that will be used for the acceptance of radioactive waste, for making choices in processing and storage and securing funding in the long term. Because COVRA is responsible for both storage and disposal, these aspects are already taken into account.

- *(Transfer of) Knowledge (knowledge of disposal, green arrows)*

  Maintenance of knowledge of the properties of the waste and the disposal facility(ies) is necessary to inform future generations of what is located belowground, and why. Thanks to rapid technological developments, information has become more transient. Information stored in digital form can only be read if the combination of hardware and software remains available. In addition to the physical retention of knowledge, the volume of information relating to disposal remains a challenge. What information is essential for future generations? Whereas in the past the idea was that a disposal facility could be forgotten, the *International Commission on Radiological Protection*

(ICRP) now recommends that following its closure, the disposal facility should remain under institutional supervision as long as possible (see document ICRP-122 *Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste*).

In (international) research programmes into disposal, much attention is focused on how this information can continue to be transferred for the very long term. Because the decision has been taken in the Netherlands to store radioactive waste aboveground for 100 years, this also allows time to learn from experiences abroad.

E.1.3. Reversible decision making

Just as in a number of other countries, reversibility or the step-by-step approach to licencing is part of the process towards disposal in the Netherlands (see chapter 6.1.3). This process is broken down into the following phases:

- the pre-operational phase: in this phase, the location is selected and investigated, the licences are applied for, and a start is made on the construction of the geological disposal facility.
- the operational phase covers the period between the placing of the drums through to the closure of the facility.
- In the post-operational phase: following the closure of the disposal facility, there will probably be (1) a period of indirect monitoring, followed by (2) a period in which no further monitoring is carried out. According to international thinking, we must strive towards extending the period of indirect supervision as long as possible.

During this process, a number of different decision-making moments can be identified (see figure E.2).

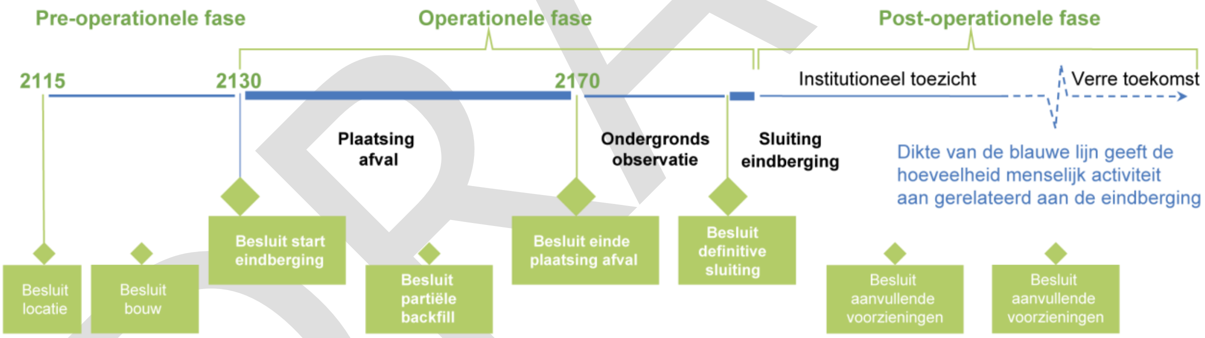

Figure E.2 Important decision-making moments in the decision-making process during the lifecycle of a disposal facility (source: OPERA, a figure from OECD/NEA adapted for the Dutch situation).

E.2 Research

The Research Programme Disposal Radioactive Waste (OPERA) is the third research programme for geological disposal in the Netherlands. Over the next few paragraphs, a summary is given of this and previous research programmes. Research from abroad will also be considered.

E.2.1 Research in the Netherlands

OPERA

The Research Programme Disposal Radioactive Waste (OPERA) is aimed at developing a roadmap for long-term research into geological disposal in the Netherlands. With this in mind, safety cases are being developed for both rock salt and Boom clay. The purpose of a safety case is to bring together all aspects that support the safety of the disposal of radioactive waste. The safety case is drawn up for a given phase in the development of a disposal facility, and integrates and evaluates the collected technical and scientific arguments and evidence for the safety of the disposal of radioactive waste. An indication is given of where there is sufficient knowledge and where more research is necessary. By periodically drawing up a safety case, research can be managed over a longer period of time. To arrive at the safety cases, a series of different studies are undertaken. COVRA coordinates these studies, that are conducted by a variety of parties. This research programme runs for five years and costs € 10 million. Of this amount, half is paid by the government and the other half by the nuclear sector. As outlined in chapter 2.4, the planning between the national programme and OPERA is not synchronous, so that the results of OPERA were not yet available during the preparation of this national programme.

Figure E.3 shows the disposal concept for clay, as currently being investigated in OPERA. This concept is based on the Belgian supercontainer concept[39].

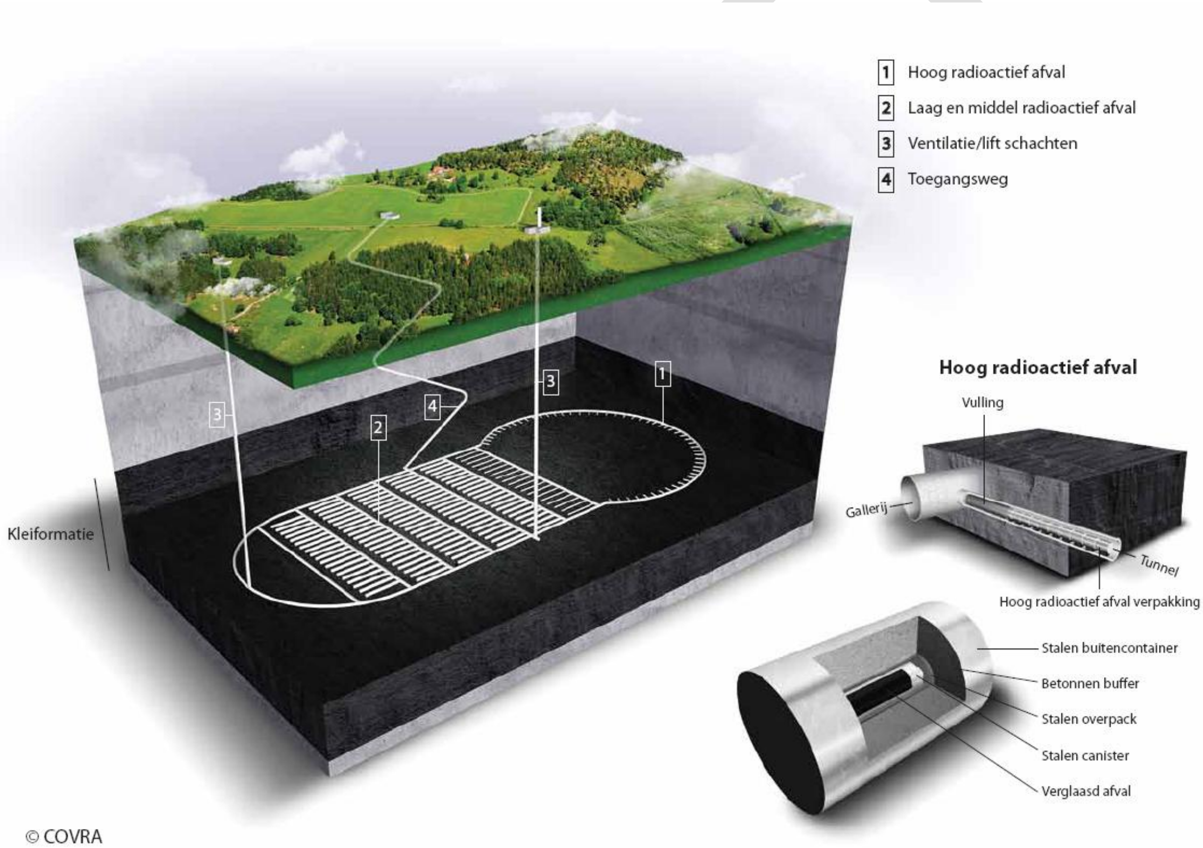

Figure E.3 Artist's impression of the disposal concept in Boom clay (OPERA).

OPLA and CORA

The first major research programme, OPLA (OPberging te LAnd (Land Storage) 1985-1993), investigated the possibilities of the disposal of radioactive waste in a geological disposal facility in salt formations in the Netherlands. It was concluded that in principle, both in technical terms and in terms of long-term safety, a disposal facility for radioactive waste in Dutch salt formations should be possible. The costs for the

39 http://www.niras.be/content/concept-van-geological-berging.

programme amounted to € 31 million.

The subsequent research programme CORA (Commission Opberging Radioactief Afval (Committee on the Disposal of Radioactive Waste), 1996-2000) aimed to investigate the possibilities of retrievability. Unlike the OPLA study, the CORA study not only considered the possibilities of disposal in salt but also in clay. The study also included the possibility of extending aboveground storage at COVRA. With aboveground storage, disposal in salt and disposal in clay, retrievability turned out to be safely possible, in principle. In total, the CORA study had a budget in excess of € 3.5 million. Both study programmes were directed by the ILONA Committee (Integraal Landelijk Onderzoek Nucleair Afval – Integrated National Research into Nuclear Waste) and were practically financed in their entirety by the Ministry of Economic Affairs[40].

E.2.2 Research abroad

In the countries around us, research is also underway into the preparation for and realisation of geological disposal facilities. Different countries have already built underground test laboratories to investigate the possibilities of disposal in geologically stable layers such as clay, granite and salt.

Belgium has a underground test laboratory, the HADES (High Activity Disposal Experimental Site) in Mol. At this location, since 1980, research has been underway into the geological disposal of high level radioactive and/or long-lived waste in Boom clay. The most suitable clay layers for the geological disposal of radioactive waste below ground in Belgium are located in the Boom and Ypresian clay layers in Northern Belgium. OPERA also cooperates with the Belgian research programme.

In a number of other countries including Finland, France and Sweden, work is underway on specific projects for creating disposal facilities. No geological disposal for high level radioactive waste is yet operational in Europe. In the United States, a geological disposal facility has been in use since 1999, in salt, for military non-heat producing radioactive waste. In the framework of this national programme, a detailed summary of the research experiences abroad has been prepared. See "State of affairs of international research into storage and disposal" (international research report).

E.2.3 International orientation and collaborations

In developing and designing Dutch policy on radioactive waste, regulations and supervision, European and other international frameworks are closely followed. Furthermore, on a voluntary basis, as far as possible, links are sought with internationally-accepted principles, recommendations, practices and agreements as established under the flag of the International Atomic Energy Agency (IAEA), Heads of the European Radiological protection Competent Authorities (HERCA) and the Western European Nuclear Regulators Association (WENRA).

The competent authority participates in a number of international organisations involved in the harmonisation of policy on radioactive waste: the European Community for Atomic Energy (EURATOM), the European Nuclear Safety Regulator Group (ENSREG), the WENRA, the Nuclear Energy Agency (NEA) within the Organisation for Economic Cooperation and Development (OECD) and the IAEA of the United Nations.

To guarantee that radiation protection remains 'state of the art', both the competent authority and COVRA participate in international peer review mechanisms. Furthermore, Dutch policy on the management of radioactive waste and spent fuel is periodically assessed by other countries, in the framework of the Joint Convention treaty under the flag of the IAEA.

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[40] Parliamentary papers, session year 2002-2003, 28 674, no. 1.

Within the European Union, there are a number of collaborations in respect of disposal. The Netherlands is a participant in or has participated in a number of these. Below are a few examples:

- *IGD-TP*
  COVRA participates in the technology platform IGD-TP (Implementing Geological Disposal of Radioactive Waste Technology Platform, www.igdtp.eu/), a European collaboration for disposal in geological layers.
- *ERDO working group*
  In the dual strategy currently being followed by the Netherlands towards disposal, international collaboration has been sought within the ERDO working group (European Repository Development Organisation-working group, http://www.erdo-wg.eu/Home.html). This working group addresses the common international challenges in managing radioactive waste. Possibilities are also being investigated of establishing a European waste management organisation.
- *SITEX*
  SITEX (Sustainable network of Independent Technical EXpertise for radioactive waste Disposal, http://www.sitexproject.eu) was a project in the framework of the seventh framework programme from Euratom. A follow-up programme will be introduced. The aim of SITEX is to strengthen and harmonise technical expertise in respect of disposal within the regulatory authorities and the supporting organisations.

Annex F – Table of concordance

The table in this annex indicates where in this national programme subjects from Directive 2011/70/Euratom can be found.

Article 12 of the Directive stipulates that Member States must indicate in their national programmes how they wish to implement their national policy for the management of spent fuel and radioactive waste. The programmes must also include the subjects covered by article 12. The table below indicates where in the Dutch national programme the subjects from article 12 of the Directive can be found.
Article 12 of the Directive has also been implemented in Dutch regulations in article 20h of the *Radiation Protection Decree* and article 40 of the *Nuclear Installations, Fissionable Materials and Ores Decree.*

Article 12	**National programme**
Paragraph one, section a 'outline objectives of national policy'	Chapter 4
Paragraph one, section b 'milestones and time frames'	Chapters 7.1 (Action points) and 7.2 (Milestones)
Paragraph one, section c 'inventory of radioactive waste and spent fuel'	Chapters 3.4.1 (current volume) and 3.4.3 (future volume)
Paragraph one, section d 'management concepts'	Chapter 4.3
Paragraph one, section e 'concepts following closure'	Chapter 4.3.3
Paragraph one, section f 'Research activities'	Annex E.2
Paragraph one, section g 'Responsibility for implementation of national programme and performance indicators'	Annex C (Competent authority) and chapter 7.3 (performance indicators)
Paragraph one, section h 'costs'	Chapter 4.5
Paragraph one, section i 'financing regulations'	Chapter 4.5.3
Paragraph one, section j 'transparency policy or process'	Chapter 6.2
Paragraph one, section k 'agreements on the management of spent fuel and radioactive waste'	Chapter 5.2