Rathenau Instituut

Taking steps together now

Advisory report on the decision-making process on the long-term management of radioactive waste

Advisory report

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Preface

How do you make decisions on an issue for which decision-making takes several decades and involves a wide range of social and technological uncertainties? What knowledge is needed, and who can have their say? These are key questions when it comes to the safe management of radioactive waste. In the Netherlands, this waste is temporarily stored above ground, with the aim of finding a definitive solution around 2100. Such a definitive solution is necessary because some of the waste remains hazardous for hundreds of thousands of years.

The *National Programme for the Management of Radioactive Waste and Spent Fuel* describes how the Netherlands intends to address this issue, now and in the future. This programme is scheduled for review in 2025. In preparation for the review, the State Secretary for Infrastructure and Water Management asked us for advice on how the government can best organise decision-making on the long-term management of radioactive waste. This advice is based on a five-year research and dialogue programme. In separate reports, we have set out how the Netherlands dealt with its radioactive waste until 2016, how other countries make decisions on this issue, which laws and regulations apply in this area, what is the current state of knowledge and how experts and stakeholders view the decision-making process.

With its current above-ground storage in the province of Zeeland, the Netherlands is well positioned to carefully shape the decision-making process. We nevertheless conclude that more action and different policies are needed to ensure effective decision-making, and to avoid missing opportunities and passing on unnecessary burdens to future generations. The government's ambitions to build new nuclear power plants also make this necessary.

We advise the government to take action now and think ahead, instead of reasoning backwards from the year 2100. This can be done by dividing the decision-making process into phases, which can last from several years to several decades. In the first phase, a disposal programme needs to be drawn up. For each phase, the government must determine in consultation with society what knowledge, policy, public participation and funding are needed so that each phase can end with a decision that brings us closer to a solution.

This advisory report shows how we can take steps together now.

Prof. Eefje Cuppen
Director of the Rathenau Instituut

Executive summary

Radioactive waste must be safely isolated from humans and the environment until it is no longer hazardous. Depending on the type of waste, this can take anywhere from a few hours to hundreds of thousands of years. The Netherlands temporarily stores its radioactive waste above ground in the province of Zeeland at the Central Organisation For Radioactive Waste (*Centrale Organisatie Voor Radioactief Afval*, COVRA). The government wants to decide on a disposal method and location for a definitive solution around the year 2100. The government envisions a geological repository in around 2130. The decision-making process on this solution still needs to be defined.

At the request of the State Secretary for Infrastructure and Water Management, this report provides advise on the decision-making process and ways to involve society. The Rathenau Instituut argues that postponing a decision until 2100 is unwise and undesirable, also in the light of the government's nuclear ambitions. For example, the Netherlands risks missing out on opportunities for international cooperation and placing unreasonable burdens on future generations. To prevent this, the government must begin implementing a step-by-step and participatory approach. The recommendations in this advisory report are intended to support such an approach.

The advisory report is based on the results of a five-year research and dialogue programme. As part of this programme, the Rathenau Instituut investigated how the Netherlands handled its radioactive waste after World War II, how other European countries decide on the disposal of their waste, what laws and regulations govern radioactive waste management in the Netherlands, and what knowledge is needed for decision-making. The Rathenau Instituut also organised workshops with experts and stakeholders, as well as focus groups with citizens on how the Netherlands can effectively shape decision-making.

The current situation in the Netherlands

COVRA stores Dutch radioactive waste for a period of at least 100 years. Around 2130, the government plans to place the waste that is still radioactive by then in a geological repository. This involves storing the waste in stable geological layers at a depth of several hundred metres. The Netherlands has salt and clay layers that could potentially be suitable for this purpose. Other options include choosing an alternative disposal method around 2100, should one become available, or continue with above-ground storage. The government plans to use the period up to 2100 to

undertake several actions, including to learn from experiences in other countries, carry out research and build capacity to finance a final repository.

Four policy principles apply to radioactive waste management in the Netherlands:
- minimising the generation of radioactive waste;
- safe management of radioactive waste;
- no unreasonable burdens on the shoulders of future generations; and
- the causers of radioactive waste are responsible for the costs of its management.

The government employs a dual strategy for long-term management of radioactive waste. This implies that 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 site will not be excluded. The government also considers it important to involve society in decision-making.

Time for action

Over the past decades, the Netherlands has developed policy, drafted legislation and conducted research for the purpose of decision-making on the long-term management of radioactive waste. However, many decisions are still required before the Netherlands has a definitive solution. Four processes are particularly important in this context, organising: (1) decision-making, (2) knowledge, (3) participation and (4) financing. The Rathenau Instituut concludes that action is needed now for these processes to contribute effectively to decision-making.

The policy of deciding on a definitive management method and location for long-term radioactive waste management until around 2100 is leading to a lack of urgency and direction. Several international organisations, experts and stakeholders are concerned about this situation because it could result in: suitable sites becoming unavailable, insufficient knowledge development, missed opportunities for multinational cooperation and passing on unnecessary burdens to future generations. In addition, the nuclear ambitions of the current and previous governments may increase the volume of waste for which the Netherlands will need to find a solution. It is therefore time for more action in decision-making.

To enhance clarity on decision-making, the State Secretary for Infrastructure and Water Management announced in late 2022 that a roadmap would be developed for a final repository. The aim of this roadmap is to outline the steps needed to realise a final repository. The State Secretary also asked the Rathenau Instituut to advise on the decision-making process.

Four recommendations for step-by-step and participatory decision-making

In this advisory report, the Rathenau Instituut makes four overarching recommendations for a participatory, step-by-step decision-making process. In this way, decision-making can start immediately and society can have their say while the options are still open. The aim of this approach is to democratically and effectively achieve a widely supported solution for the long-term management of radioactive waste. The recommendations are:

1. lay down a participatory, step-by-step approach now;
2. determine through a participatory process which disposal methods the Netherlands wishes to explore and further develop;
3. divide the decision-making process into five phases; and
4. organise decision-making, public participation, knowledge and financing at each step.

Lay down a participatory, step-by-step approach now

The Rathenau Instituut recommends that the government establishes a participatory, step-by-step approach to decision-making in the 2025 *National Programme for the Management of Radioactive Waste and Spent Fuel*. This programme describes how the Netherlands intends to ensure safe management now and in the future. The decision-making phases outlined in this advisory report can be adopted by the government within the programme, providing an overview of the different phases without laying them down in detail.

This approach differs from the government's current strategy of setting an end goal and reasoning backwards, which involved only developing a roadmap for a final repository and adhering to the timeframes of 2100 and 2130. In contrast, a step-by-step and participatory approach reasons forwards. Dividing the process into small steps creates focus and flexibility. It allows for a quicker start and makes the process more manageable, making it easier to sustain progress. Moreover, this approach helps to deal with the uncertainties associated with long-term decision-making.

Starting now does not imply rushing, but means that decisions regarding disposal method(s) and timeframe(s) follow from the steps taken in consultation with society. This approach enables the government to avoid prematurely selecting solutions or choices that may later prove unsuitable or lack public support.

Determine through a participatory process which disposal methods the Netherlands wants to explore further

The Rathenau Instituut recommends exploring multiple disposal methods and associated routes. The government currently has the intention to develop solely the route to a geological repository. However, exploring various options is important in order to have alternatives available if geological disposal proves unfeasible or

undesirable, or if better techniques become available to manage all or part of the waste. In addition, considering the current nuclear ambitions, it may prove wiser to manage high-level waste and low and intermediate-level waste by different methods, such as geological disposal combined with surface disposal.

Exploring different disposal methods also enables society to participate in decision-making while choices are still open. This is a recommendation made by international organisations. The Rathenau Instituut recommends that the government draw up a disposal programme that includes several disposal methods to be further researched and developed and a corresponding prioritisation of methods. The government should coordinate and evaluate the disposal programme. For evaluation points, it can use the *National Programme* review and progress reports and key decisions. This approach will enable interim learning and, where necessary, adjusting, stopping or adding roadmaps.

The Rathenau Instituut recommends that the disposal programme should also explicitly state which multinational options the Netherlands wants to explore, and that opportunities for multinational cooperation should also be considered when developing the national roadmaps. The government can announce that it will prepare a disposal programme in the 2025 *National Programme,* in which it can also mention some alternative disposal options that could be included in the programme besides geological disposal. It is crucial to then assess the feasibility and desirability of these options in proper consultation with society and to develop and adopt the disposal programme.

Divide the decision-making process into five phases

The Rathenau Instituut recommends dividing the participatory and step-by-step approach to decision-making into five phases.

1. **Initiation phase**. The aim of this phase is to develop a disposal programme that has broad public and political support. This phase can commence after the 2025 *National Programme* has been adopted and is expected to take five to ten years. This will allow time to update policies and legislation, research and assess various disposal methods, develop roadmaps and consult a broad public on these matters.
2. **Development and siting phase.** In this phase, the implementation of the disposal programme starts. When a roadmap is successfully implemented, this phase moves step by step towards a location for the realisation of the chosen disposal method. Experiences in other countries show that this is a socially and politically sensitive process. Involvement of decentralised authorities and local communities is therefore essential.
3. **Construction and operation phase.** This phase starts after approval of a licence application to implement the disposal method at a particular location.

This phase focuses on the construction of a radioactive waste disposal facility, and if found safe, placement of the waste.

4. **Closure phase.** In this phase, a facility is closed if necessary. This requires agreement on the period of retrievability, the method of closure and any decommissioning of the placement facility.
5. **Post-closure phase.** In this phase after closure of the disposal facility, passive safe management takes place, requiring no more efforts to maintain safety. However, a decision may be made to continue monitoring the facility's environment for a certain period of time.

These five phases are similar to timetables recommended by international organisations for the implementation of a geological repository. A key difference is that the Rathenau Instituut recommends establishing a disposal programme with multiple disposal methods in the initiation phase. Each disposal option will thus have its own decision-making process and roadmap. Phases 2 to 5 will be developed for each option with their own timeline. This is because research into geological disposal may take more time than research on surface disposal. Moreover, not every option needs to go through all the phases: they can be halted if an option proves undesirable.

Organise decision-making, knowledge, participation and financing at each step

The Rathenau Instituut recommends establishing how decision-making, knowledge, public participation and financing will be organised at the beginning of each phase. These four processes are important to arrive at informed and legitimate decisions.

This advisory report presents generic recommendations and action points for each of the four processes during the initiation phase (see Chapter 3 and, for an overview, Appendices 1 and 2). The action points relate to the start and implementation of the initiation phase. See below for a summary.

Start of the initiation phase

At the beginning of the initiation phase, the government needs to establish how the four processes mentioned above will be organised within that phase. This means clarifying what the decision-making in that phase is about, who can take part, when and for what purpose, what knowledge is needed at different times and what resources are needed for this. The government also needs to determine how this will be organised and assign tasks and responsibilities throughout the process.

It is essential that experts and stakeholders are involved in the government's decisions at an early stage. Such discussions can be supported by an independent party with appropriate expertise that is politically neutral and separate from the

companies and institutions that produce radioactive waste. It is important to anchor the approach in policy and, when appropriate, legislation, as this can help secure commitment from the government and parliament, and increase the legitimacy of decision-making.

The government holds primary responsibility for organising the initiation phase. This involves significant work, not only to organise decision-making, but also to organise participation, knowledge and financing. The Rathenau Instituut therefore advises the government to expand the currently limited capacity and expertise within the responsible ministry.

The approach should include arrangements on the following.

- **Organising decision-making.** The approach to decision-making should clarify what steps will be taken in the initiation phase, what principles apply to decision-making and who is responsible for implementation. The government may outsource specific tasks needed to achieve this approach to an independent organisation.
- **Organising public participation.** The approach to public participation should clarify how participation activities and processes tie in with each other and with the steps in the initiation phase. It should also be clear who coordinates and implements the approach to participation. An independent organisation with appropriate expertise can be hired to implement participation. The approach should also clarify how public participation will be evaluated.
- **Organising knowledge.** The approach for knowledge consists of a knowledge agenda in line with the needs in the initiation phase and agreements on who will implement it. The Rathenau Instituut recommends using an independent party with the necessary expertise to develop this knowledge agenda. The knowledge agenda should guide research and contribute to better information provision, tie in with national and international initiatives and encourage diversity in knowledge and knowledge providers.
- **Organising finances.** Organising all these processes requires funding. The approach to finance therefore needs to include a transparent cost estimate for the initiation phase and clarify who pays what and how monitoring will be arranged.

Implementation of the initiation phase

The initiation phase should lead to a disposal programme. This is done by determining through a participatory process which disposal methods the Netherlands wants to further explore through various roadmaps. For this, the Rathenau Instituut recommends first updating and elaborating on the policy

principles described above. These principles should guide the selection and assessment of disposal options, but are currently not sufficiently developed to be used as a benchmark for this purpose.

Once it has been decided which roadmaps should be drawn up, the next step is to determine how decision-making, knowledge, public participation and financing will be organised for each of these roadmaps. This mainly involves overarching agreements on who is responsible for these processes and on the substantive elaboration and coordination of these processes. Some roadmaps will last for many decades, so it is essential that these agreements ensure continuity.

From a certain point onwards, research into a disposal method is inextricably linked to the location selection process, for example due to exploratory drilling or the need for an underground research facility. Therefore, when drawing up the disposal programme, it is essential to establish agreements on organising decision-making, knowledge, participation and financing in this regard. These steps are socially and politically sensitive. Special attention to the involvement and knowledge position of decentralised authorities and local communities is crucial here.

Finally, the Rathenau Instituut recommends reaching agreements on the periodic evaluation of the disposal programme. The 10-year updates of the *National Programme* present an appropriate opportunity, as do the three-yearly reports on the programme's implementation. It must be clear what criteria will be used to assess disposal options and how scientists, businesses, civil society organisations and citizens will be involved.

Contents

List of abbreviations

ANVS	Authority for Nuclear Safety and Radiation Protection (*Autoriteit Nucleaire Veiligheid en Stralingsbescherming*)
CHVRA	Committee for Reconsidering the Disposal of Radioactive Waste (*Commissie Heroverweging Verwijdering Radioactief Afval*)
COVRA	Central Organisation for Radioactive Waste (*Centrale Organisatie voor Radioactief Afval*)
ERDO	European Repository Development Organisation
Euratom	European Atomic Energy Community
IAEA	International Atomic Energy Agency
NEA	Nuclear Energy Agency
NORM	Naturally Occurring Radioactive Material
NRG	Nuclear Research and Consultancy Group
OPERA	Research Programme for the Geological Disposal of Radioactive Waste (*Onderzoeksprogramma Eindberging Radioactief Afval*)
RIVM	National Institute for Public Health and the Environment (*Rijksinstituut voor Volksgezondheid en Milieu*)
SCK-CEN	Belgian Nuclear Research Centre (*Studiecentrum voor de Toepassingen van Kernenergie*)
TNO	Netherlands Organisation for Applied Scientific Research (*Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek*)
VNG	Association of Netherlands Municipalities (*Vereniging van Nederlandse Gemeenten*)
VROM	Ministry of Housing, Spatial Planning and the Environment (*Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer*)

Introduction

The Netherlands generates radioactive waste every day, for example in nuclear power plants, hospitals, laboratories and industry. This waste emits radiation that can be harmful to both humans and the environment. The radiation decreases over time, until the waste is no longer hazardous. The duration of this process depends on the type of waste and can range from a few hours to hundreds of thousands of years. It is crucial to safely isolate radioactive waste from the living environment for as long as needed.

Forty years ago, the government decided to store radioactive waste in a central location in the Netherlands. This above-ground storage, located in the province of Zeeland at the Central Organisation For Radioactive Waste (COVRA), is intended to be a temporary solution for at least 100 years. The government wants to decide on a method and location for a definitive solution around the year 2100. The government assumes that a geological repository will be operational around 2130. However, decision-making on the long-term management of radioactive waste has yet to be completed.

In 2019, the State Secretary for Infrastructure and Water Management asked the Rathenau Instituut to provide advise on what this decision-making process could look like and how society could be involved. The result is this advisory report, which serves as input for the second *National Programme for the Management of Radioactive Waste and Spent Fuel*, due in 2025. The programme will outline how the Netherlands intends to manage radioactive waste safely, now and in the future. It will be an update of the first *National Programme* from 2016.

This advisory report is based on a combination of research and dialogue with experts and stakeholders. The Rathenau Instituut concludes that much work remains to be done before the Netherlands has a definitive solution. Waiting until 2100 to make decisions is unwise and undesirable. The government must begin today with a step-by-step, participatory approach to decision-making that provides the necessary direction and urgency. This advisory report offers recommendations for this purpose.

Background: radioactive waste in the Netherlands

This advisory report deals with decision-making on the long-term management of radioactive waste. In the Netherlands, the term ‘radioactive waste’ refers to a radiative substance that is not expected to be used or reused. Radioactive waste must be safely managed until it decays to below release limits. To determine how waste should be managed, the Netherlands distinguishes four waste categories (Burggraaff et al., 2022).

- **High-level radioactive waste**. This is highly radioactive waste from nuclear energy production (67%), medical isotope production (29%) and research and education (4%). This waste is stored at COVRA.
- **Low-level and intermediate-level radioactive waste, including naturally occurring radioactive waste (NORM waste)**. Low-level and intermediate-level waste has lower radiation levels than high-level waste and is generated by facilities such as hospitals, laboratories and nuclear power plants. This category includes NORM waste, which accounts for the largest volume of waste. This waste is produced by activities such as uranium enrichment at Urenco and industrial processes, for example involving the concentration of phosphate ores. COVRA stores low-level and intermediate-level waste, including a small percentage of NORM waste. Most of the NORM waste (99%) has such low radioactivity that it can be disposed of in designated waste disposal sites (landfills) or mixed with non-radioactive material so that it can be reused.
- **Short-lived radioactive waste**. This is waste with a short half-life, generated at for example hospitals and research facilities. The half-life indicates the rate of radioactive decay. Short-lived waste has a half-life of less than 100 days and may be stored at the producer for two years. It decays to below the release limits within this period.
- **Exempt waste.** As this waste has very low radioactivity, special treatment is not or no longer needed. It may be treated as conventional waste.

Amount of radioactive waste in the Netherlands
Every year, the Netherlands generates nearly 114 thousand m³ of radioactive waste, with COVRA receiving approximately 1% of this (Burggraaff et al., 2022). Compared to the other types of waste at COVRA, high-level waste has the smallest volume but the largest proportion of radioactivity (see figure 1).

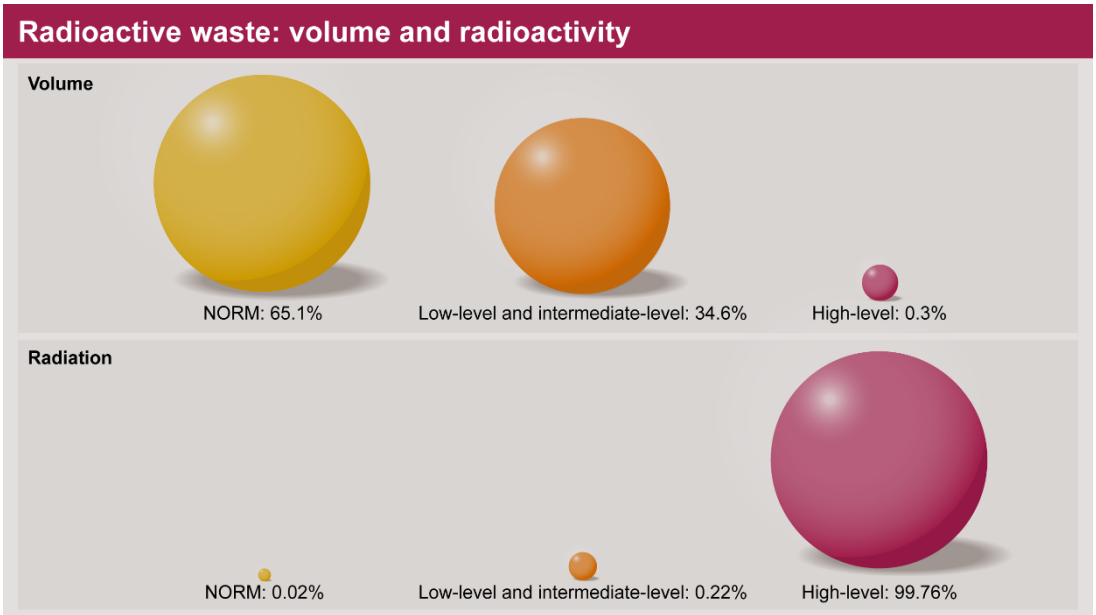

Figure 1 The contribution of different waste categories to the total volume and total radioactivity of waste at COVRA. This figure is presented in three dimensions, and NORM is included as a separate category of waste (bron: Burggraaff et al., 2022).

Long-term management of radioactive waste

Radioactive waste must be managed safely as long as it poses a danger to humans and the environment. Management includes all operations related to handling, pre-treatment, treatment, conditioning, storage and, if necessary, final disposal of radioactive waste.

The government wants to place all low-level, intermediate-level and high-level radioactive waste currently stored at COVRA, and still radioactive in 2130, into a deep geological repository. This involves storing the waste in stable geological layers at a depth of several hundred metres (see Figure 2). The Netherlands has salt domes and clay layers that may be suitable for this purpose.

It is not yet clear how much radioactive waste will go into any repository in 2130. In the 2022 waste inventory, COVRA estimates that the final volume of conditioned high-level radioactive waste to be disposed will be 8,050 m³. COVRA based this calculation on the rate of nuclear waste production at that time (Burggraaff et al., 2022). The exact amount will depend on several factors, including nuclear policy and legislation, for example on radiation protection regulations. Changes in industrial processes, packaging requirements and new waste disposal methods can also affect the final volume. Sometimes waste needs additional packaging such as for final disposal, which can increase the overall volume.

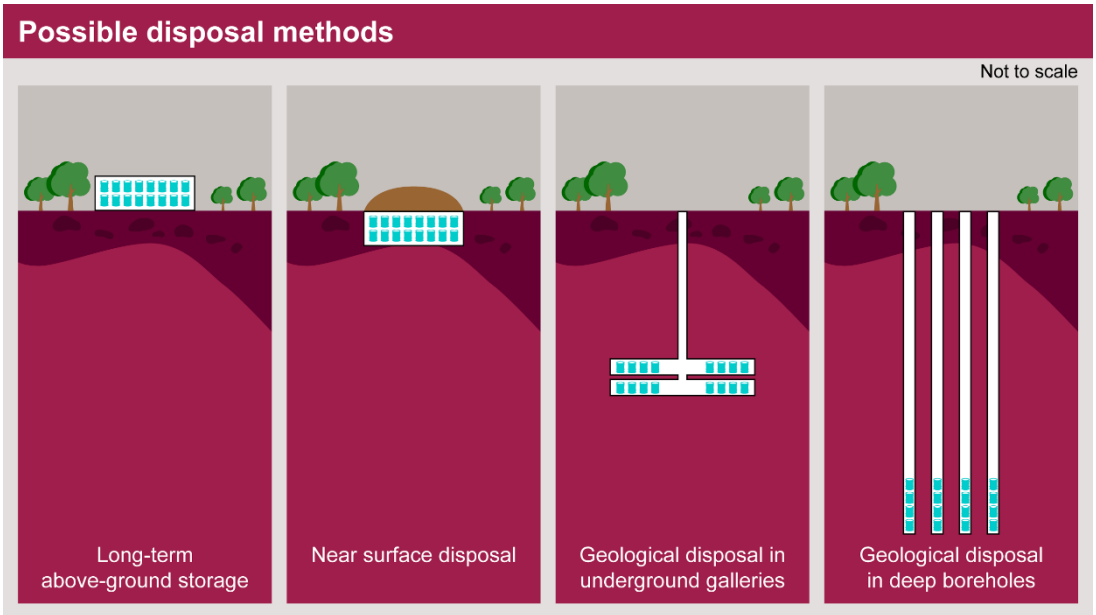

Figure 2 Overview of possible management methods

If the Netherlands uses more nuclear power than previously anticipated, the amount of radioactive waste will increase and the inventory will change. For example, COVRA calculated that adding two new nuclear power plants, extending the lifespan of the Borssele nuclear power plant beyond 2033, building a new medical isotope reactor (Pallas) and an isotope plant in Veendam will increase the volume of high-level waste by a factor of 20 (3.5 thousand m³ extra) and low-level and intermediate-level waste by a factor of 4 (77 thousand m³ extra) by 2130 (Burggraaff et al., 2022).

The government aims to decide on a definitive solution for the long-term management of radioactive waste around 2100. It may therefore choose a management method other than deep geological disposal, such as long-term above-ground storage, near surface disposal, deep boreholes or a combination of management options (see Figure 2). Thereafter, the government intends to look for a suitable location to implement the chosen management option or options.

Scope: the Rathenau Instituut's perspective

It is not yet known how the government intends to decide on the long-term management of radioactive waste. The State Secretary for Infrastructure and Water Management has asked the Rathenau Instituut to advice on how to shape this decision-making process and how to involve society in this. In consultation with the ministry, the Rathenau Instituut has defined the scope of this request as follows.

Radioactive waste at COVRA
This advisory report focuses on the high-level, low-level and intermediate-level radioactive waste (including NORM waste) stored at COVRA, now and in the future, and destined for final disposal. A definitive, long-term solution needs to be found for this waste. The part of NORM waste that is disposed of in designated landfills due to lower radioactivity falls outside the scope of this advisory report because these landfills are already a final disposal site. Short-lived waste and exempt waste are also outside the scope of this advisory report because they do not require long-term management.

Decision-making as a broad democratic process
In this advisory report, the term ‘decision-making’ refers to the broad democratic process within which decisions are made. This proces involves the central government but also scientists, companies, civil society organisations, decentralised authorities and citizens. These actors can provide valuable knowledge and represent interests of groups affected by decision-making. Ideally, decision-making on radioactive waste management takes place within, and in interaction between four domains: politics and governance, science and technology, legislation, and wider society. These domains include different levels of governance: from international to local (see Figure 3).

The domains of this ‘governance ecosystem’ form the institutional and organisational setting within which decisions are made, participation takes place, knowledge is developed and financing is arranged. These four processes shape the long-term management of radioactive waste. European Directive 2011/70/Euratom imposes legal obligations on Member States to ensure that these processes are organised properly (2011/70/Euratom).

The functioning of the governance ecosystem determines the extent to which these processes (decision-making, participation, knowledge development and financing) contribute to effective solutions that enjoy broad public support (Arentsen & Van Est, 2023). Therefore, the recommendations in this advisory report focus on how the Netherlands can design its governance ecosystem to ensure that these processes contribute in a democratic and effective way to achieving a definitive solution for the long-term management of radioactive waste.

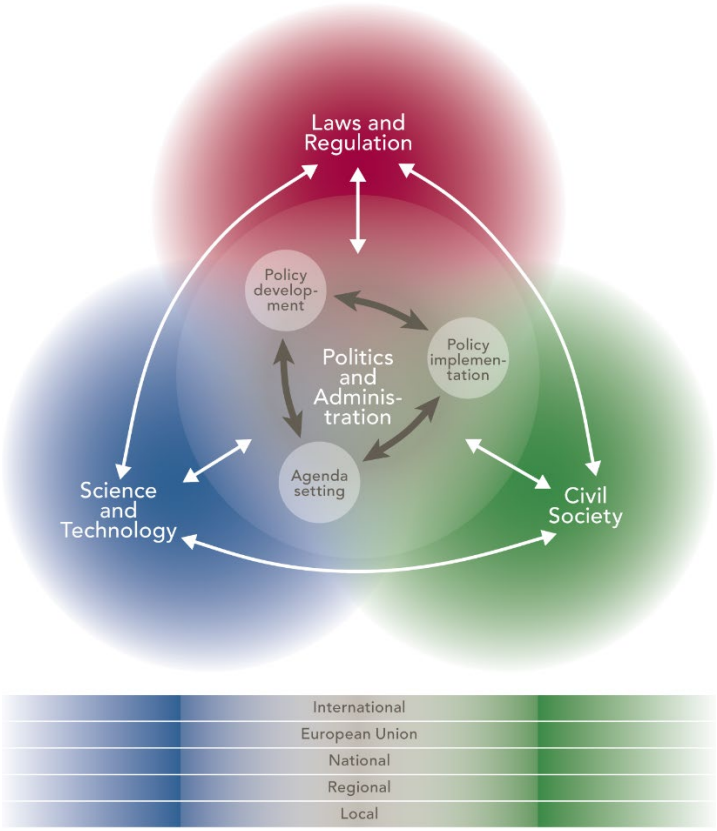

Figure 3 The multi-level governance ecosystem framework (Van Est et al., 2023, adapted to Kool et al., 2017, p. 95).

Public participation

Public participation is an important part of decision-making on radioactive waste management. EU Member States are obliged to involve society in the decision-making process (2011/70/Euratom). In 2015, the Rathenau Instituut prepared a vision on public participation for the government to inform the first *National Programme* (ministerie van Infrastructuur en Milieu, 2016).

The Rathenau Institute defines public participation in decision-making as participation by society at large, consisting of different types of public: the scientific community, authorities, citizens and other stakeholders such as businesses and civil society organisations. Public participation should be organised on a case-by-case basis for each issue to be addressed. The method of participation and participants can thus be tailored to the purpose, such as selecting a disposal method or siting a disposal facility.

In 2015, the Rathenau Instituut advised the government not to start public participation yet due to a lack of urgency and concrete decision-making. Instead, it recommended to prepare for this process (Rathenau Instituut, 2015). The

government adopted this advice in the 2016 *National Programme*. This advisory report finds that there is now a need for more direction and urgency in decision-making and makes recommendations for embarking on a step-by-step approach to decision-making, including public participation.

Public participation is essential for democratic and effective decision-making on long-term radioactive waste management, but it does not guarantee success. Poorly organised participation can do more harm than good. Based on research and interviews with stakeholders and experts, this advisory report therefore clarifies when, on what issues, and by whom participation can take place, and makes recommendations on what is needed to ensure it effectiveness.

Approach: research and dialogue

This advisory report is based on the results of a five-year research and dialogue programme designed as a knowledge and learning process where research and dialogue influence each other. This means that research has informed the dialogue, and the outcomes of dialogues have guided further research. The results of these activities form the foundation of this advisory report. The programme consisted of four lines of research and dialogue: past, present, future and elsewhere. This section discusses the main activities that took place within these lines.

Past
The Rathenau Instituut collaborated with the Foundation for the History of Technology (*Stichting Historie der Techniek*) to study how Dutch radioactive waste policy has developed over the past 70 years. Knowledge about the past helps to better understand current policies. It also provides insights for future decision-making. For example, the study *A question of time* (*Een kwestie van tijd*) indicates that insufficient involvement of society in decision-making can lead to resistance and opposition (Rathenau Instituut, 2023b). The Rathenau Instituut also spoke to 22 stakeholders and experts about a draft version of the study. The results are summarised in the report *History as a conversation starter (Geschiedenis als gesprekstarter)* (Rathenau Instituut, 2023c).

Present
Effective and democratic decision-making requires a well-functioning governance ecosystem. In early 2020, the Rathenau Instituut therefore explored how the governance ecosystem around radioactive waste management functions. The Rathenau Instituut spoke to 23 stakeholders and experts about what was going well and what could be improved. These discussions revealed a need for an overview of legislation governing the long-term management of radioactive waste. There were also concerns about the knowledge base in the Netherlands for radioactive waste management and the vitality of the knowledge community. Finally, there was much demand for lessons from abroad. In response, the Rathenau Instituut launched two projects and the additional line of research ‘elsewhere’ (see below).

For the first project, the Rathenau Instituut collaborated with Utrecht University to analyse the legal framework for decision-making on the long-term management of radioactive waste. Legislation and regulations define the criteria that long-term radioactive waste management must meet, and the responsibilities of parties involved in this management. They also give citizens the right to access information, participation and appeal. The study *Rules for radioactive waste management* (*Regels voor het beheer van radioactief afval*) provides an overview of the relevant international, European and national rules and reveals potential gaps (Rathenau Instituut, 2024c).

For the second project, the Rathenau Instituut investigated how knowledge for long-term radioactive waste management is developed, managed and utilised in the Netherlands. Knowledge is needed to determine how and where the Netherlands can dispose of the waste. It is important that citizens and stakeholders have confidence in how this knowledge is developed. Based on research, interviews and two workshops, the study *Heading for knowledge (Koersen op kennis)* indicates what is going well and where there is room for improvement when it comes to knowledge (Rathenau Instituut, 2024b).

Elsewhere
All European countries are seeking a solution to their radioactive waste. Finland, Sweden and France are the frontrunners in this endeavour. These countries have already decided on a specific disposal site and are currently working on realizing a geological repository. Many other countries are still in the process of finding suitable sites. The Netherlands can learn from the experiences of other countries. That is why the Rathenau Instituut, in collaboration with scientists from other countries, produced the book *The future of radioactive waste governance: Lessons from Europe* (Arentsen & Van Est, 2023).

The book describes and compares the radioactive watse management policies of ten European countries. It shows how national governments have learned to involve local governments, civil society organisations and citizens in the decision-making process. This is referred to as the participatory turn (Arentsen & Van Est, 2023; Bergmans et al., 2015). The study shows that this participatory turn was accompanied by the arrival of new institutions such as independent organisations and changes in legislation. These are designed to ensure fair processes and an equal distribution of knowledge and power.

In October 2023, the Rathenau Instituut organised a meeting where national and international experts discussed the implications of the book's insights for the Netherlands (Rathenau Instituut, 2024a).

Future

To explore how the Netherlands can effectively organise decision-making on long-term radioactive waste management, the Rathenau Instituut organised dialogue activities centered around six topics: management method, location, financing, cooperation with other countries, the decision-making process and public participation (Rathenau Instituut, 2023d).

At a workshop in summer 2023, 28 policymakers from national and regional authorities, researchers, entrepreneurs, civil society organisations and other stakeholders discussed the main issues and challenges for future decision-making on radioactive waste (Rathenau Instituut, 2024a).

Later that year, 33 stakeholders and experts discussed the trade-offs involved in decision-making on the six issues mentioned above. They did so using case studies based on foreign examples (Rathenau Instituut, 2024a).

Finally, the Rathenau Instituut organised four meetings with groups that were not represented in the earlier workshops but that may be affected by decision-making on the long-term management of radioactive waste: young people and residents of the province of Zeeland (Rathenau Instituut, 2024e). Young people will have to deal with the consequences of the decisions that will be made for longer than older people. Residents of Zeeland live in the province where the current storage site is located. Although the location of a possible final repository has not yet been determined, decisions on radioactive waste management will affect their region.

Justification

This section explains why the Rathenau Instituut drew up this advisory report and how it came about, the quality checks, the utilisation of dialogue activity results and the influence of external developments on the advice.

Expertise
The Rathenau Instituut has been researching the impact of science, innovation and technology on society for over 35 years. It has previously published reports on socially sensitive topics, such as shale gas and geothermal energy (Rathenau Instituut, 2013, 2017), and on public participation in the energy transition (Rathenau Instituut, 2016). At the request of the Dutch government, it formulated a vision for public participation in the long-term management of radioactive waste (Rathenau Instituut, 2015), which serves as a foundation for the current research and dialogue programme.

Quality assurance
The Rathenau Instituut has taken several steps to ensure the quality of this advisory programme. An external advisory committee advised on quality and social and political embedding (see: Appendix 3). All reports went through an internal quality procedure and were checked for factual inaccuracies by experts and stakeholders. All dialogue meetings were evaluated for interim learning.

Results of dialogue activities
The Rathenau Instituut involved various publics from different domains of the governance ecosystem in the dialogue activities to gather a wide range of views and perspectives. The outcomes of all dialogue activities were incorporated into reports published on the Rathenau Instituut's website. Participants' input was summarised in workshop reports, ensuring that all views and ideas were given equal weight in the process. Differences in views and opinions were highlighted as much as possible. Workshop participants were not required to agree or reach a consensus. To do justice to what was said in the workshops, any factual inaccuracies in participants' comments have not been corrected in the reports.

In this advisory report, the Rathenau Instituut uses input from participants in dialogue activities in several ways. Firstly, it serves as illustrations of views and opinions that exist in society on the subject. Secondly, it provides valuable insights into key issues, trade-offs and possible solutions. Quality assurance was carried out to check for factual inaccuracies. Ultimately, the conclusions and recommendations based on input from participants in the dialogue activities are solely the responsibility of the Rathenau Instituut.

Changing context
Several key events occurred during the five years the Rathenau Instituut worked on this advisory programme. In 2020, the COVID-19 pandemic broke out and in 2022, Russia's invasion of Ukraine started a war on the European continent, contributing to an energy crisis. The pandemic resulted in fewer in-person meetings than intended, with interactions primarily taking place online for two years. This includes interviews, collaborations with scientists from other countries and the dialogue session on the historical study.

In addition, Dutch nuclear energy policy underwent significant change, partly in response to the climate and energy crises. When this advisory process started in 2019, the nuclear sector appeared to be shrinking, with the Borssele nuclear power plant scheduled for closure in 2033. At the time of publishing this report, the situation has changed. The Fourth Rutte government (January 2022–July 2024) sought to extend the operational period of the nuclear power plant in Borssele and opted to build two new plants. It also freed up funds for research into smaller modular nuclear power plants, known as Small Modular Reactors (SMRs). The Schoof government, which took office in July 2024, is advocating the construction of four new nuclear power plants. In addition, two companies are working on new facilities for medical isotopes and uranium enricher Urenco is to increase production by 15%.

Finally, it is important to mention that during the last two years of this research and dialogue programme, the King Baudouin Foundation in Belgium organised a public debate entitled *Now for tomorrow: Dialogue on the future of radioactive waste (Nu voor morgen: Dialoog over de toekomst van radioactief afval)*. This debate was about the long-term management of high-level and long-lived waste in Belgium (Koning Boudewijnstichting, 2024a). The Rathenau Instituut was in regular contact with the organisers of this event.

Reading guide

Chapter 1 of this advisory report describes the background to Dutch policy on radioactive waste management. It discusses the current situation and shows that several challenges require attention. It also discusses the views of international organisations, experts and stakeholders on current policies. The Rathenau Instituut concludes that decision-making on the long-term management of radioactive waste needs more urgency and direction, which requires a step-by-step, participatory decision-making approach.

Chapter 2 outlines recommendations for a stepwise, participatory approach, which the government can adopt to take steps together with society. This approach consists of five phases in which a disposal programme is drawn up and implemented.

Chapter 3 expands on this and discusses what is needed to implement that approach. It makes recommendations for organising decision-making, public participation, knowledge and financing, and discusses specific actions that can start in the immediate period ahead. Appendices 1 and 2 provide point-by-point overviews of these action points for the beginning of this first phase and for its execution.

Finally, Chapter 4 presents the key message of the advisory report.

1 Time for action

Forty years ago, the government decided to temporarily store radioactive waste above ground and to postpone adopting a definitive solution for its long-term management until around the year 2100. Since then, significant progress has been made in research, policy and legislation. However, further action is needed to ensure democratic and effective decision-making. The current policy lacks the urgency and direction to take the steps that are needed in the coming years. Experts and stakeholders express concerns that this inaction could result in the Netherlands to miss opportunities and pass on unreasonable burdens to future generations. A new approach is needed in which the government works with society to take clear steps in the long-term management of radioactive waste.

1.1 Background: radioactive waste policy

The decision to opt for long-term above-ground storage of radioactive waste dates back to 1984. A major reason for this was public opposition to the dumping of low-level and intermediate-level radioactive waste in the ocean and the subsequent international ban on such activities (Rathenau Instituut, 2023b). As a result, the government had to look for other ways to manage this waste. A solution was also needed for high-level radioactive waste. This waste went to reprocessing plants in France and England to extract reusable substances. The remaining waste would eventually return to the Netherlands.

The government commissioned research into several options for managing low-level, intermediate-level and high-level waste (Rathenau Instituut, 2023b). At that time, options considered included geological disposal in underground salt layers and long-term temporary above-ground storage for up to 150 years (CHVRA, 1983). Geological disposal in salt layers did not appear feasible in the short term due to its social sensitivity. The government's announcement of exploratory drilling in the north-eastern provinces of the Netherlands in 1976 led to widespread regional protests. In response, the government decided to cancel the plans for exploratory drillings and not to conduct on-site geological disposal studies for the time being (Rathenau Instituut, 2023b).

Against this backdrop, the government opted for central above-ground storage of radioactive waste (VROM, 1984). This gave the Netherlands more time to build up financial resources, conduct further research into disposal methods and learn from

developments in other countries. It was expected that several countries would commission a final repository in the meantime and that the Netherlands could possibly join an international disposal facility. An additional advantage of temporary storage was that the radiation of the waste gradually decreases (VROM, 1984). After 100 years, some of the waste would no longer require placement in a final repository and could possibly even be reused.

1.2 Developments surrounding long-term management

Over the past 40 years, Dutch radioactive waste management policy has largely remained unchanged. COVRA stores low-level, intermediate-level and high-level radioactive waste above ground in special buildings in Zeeland for a period of at least 100 years. The government plans to place any waste that is still radioactive around 2130 in a geological disposal facility (ministerie van Infrastructuur en Milieu, 2016). Around 2100, the Netherlands intends to decide on a final management option and then look for a suitable site. It is also possible at that point to opt for a new technology for long-term management, should it become available, or to extend the duration of above-ground storage (ministerie van Infrastructuur en Milieu, 2016).

The Netherlands has taken several steps since 1984 to further shape decision-making on long-term radioactive waste management and establish the necessary institutions. This includes further developing policy, introducing legislation, conducting research, creating a financing structure, and seeking cooperation with other countries. The approach to decision-making and how to involve society has also changed. Below, we explain these developments in greater detail and outline where the Netherlands stands today.

Policy and legislation
The government presented the first *National Programme for the Management of Radioactive Waste and Spent Fuel* in 2016. The *National Programme* sets out the policy for radioactive waste management. This policy is based on four principles (ministerie van Infrastructuur en Milieu, 2016).

- **Minimising the generation of radioactive waste**. The production of radioactive waste needs to be limited as much as possible.
- **Safe management of radioactive waste**. Waste must be managed safely as long as it poses a risk to humans and the environment.
- **No unreasonable burdens on the shoulders of future generations.** Generations that benefit from certain uses of radioactivity, such as nuclear power or medical isotopes, should bear the burden of managing the resulting waste.

- **The causers of radioactive waste are responsible for the costs of its management.** Polluters should bear the cost of radioactive waste management, or in other words: the polluter pays.

In addition to the above four principles, the government imposes two additional conditions on the long-term management of radioactive waste and associated decision-making: retrievability of radioactive waste and reversibility of decision-making. Retrievability implies that it should be possible to take back radioactive waste during the use of a repository, for example if the repository does not function to an adequate standard or if techniques become available to reuse the waste. Reversibility of decision-making implies that it must be possible to reverse steps in the decision-making process.

The Netherlands has also further developed the legal framework for the management of radioactive waste. A review of this framework shows that all international and EU rules in this area have been implemented (Rathenau Instituut, 2024c). For example, regulations are in place for the safe handling of radioactive waste. To avoid conflicts of interest, responsibilities for energy policy and nuclear safety and radiation protection policy have been allocated to various government bodies (Rathenau Instituut, 2023b). Policy preparation is also separate from regulating. For example, the Ministry of Infrastructure and Water Management devises policy, while the Authority for Nuclear Safety and Radiation Protection (ANVS) oversees nuclear safety and radiation protection, and bears responsibility for licensing.

Research

The Netherlands developed knowledge regarding long-term radioactive waste management through several multi-year national research programmes (Rathenau Instituut, 2023b, 2024b). These programmes were typically initiated in response to specific policy questions and have contributed to policy development. The research programmes focused primarily on acquiring knowledge about geological disposal in salt, and later also in clay. No research has yet been carried out into specific locations, partly due to the fact that this is a sensitive issue within society (Rathenau Instituut, 2023b). However, the Netherlands uses knowledge gained from geological research conducted in countries such as Belgium and Germany.

In addition to geological disposal, the Netherlands also investigated other disposal methods (Rathenau Instituut, 2023b). In the 1980s, the option of disposing of radioactive waste under the seabed was rejected in the 1980s because it was considered too expensive. Extending the duration of above-ground storage at COVRA to 300 years turned out to be technically feasible, but would require sufficient political and legal stability (Scholten, 1998). Another option examined was

partitioning and transmutation: a processing method that can shorten the lifespan of high-level radioactive waste. This technology cannot yet be deployed on a large scale and is not a standalone disposal option (SCK-CEN & ONDRAF/NIRAS, 2019). Moreover, the options for this method proved to be limited for the Netherlands, as high-level waste returning from foreign reprocessing plants is enclosed in solid glass. Partitioning and transmutation is no longer possible for this ‘vitrified’ waste.

There are currently no ongoing multi-year national research programmes. However, COVRA has its own research programme focused on final disposal in clay and salt, and collaborates with other parties for this purpose (Rathenau Instituut, 2024b). Unlike previous research programmes, the government is not directly involved in this endeavour. In addition, this programme focuses mainly on developing technical knowledge. The focus on social science and humanities research into the long-term management of radioactive waste has generally increased, partly due to this Rathenau Instituut advisory process.

Financing

The Netherlands is obliged to have sufficient financing available for the management of radioactive waste, both now and in the future (IAEA, 1997, Art. 22; 2011/70/Euratom, 2011, Art. 9). In line with the ‘polluter pays’ principle, waste producers in the Netherlands pay a fee when transferring their waste to COVRA. This transfer constitutes full and final discharge: COVRA becomes the owner of the waste and the producers are no longer responsible for the waste and its disposal after payment. COVRA sets these fees based on an estimate of storage costs and the cost of geological disposal. The ANVS ensures that the tariffs are objective, transparent and non-discriminatory, but does not supervise the cost estimates (ANVS, 2024). In 2017 the cost of final disposal was estimated at €2.05 billion (Verhoef et al., 2017).

To ensure it has sufficient assets to process and manage the radioactive waste, COVRA invests part of the waste fees in shares and other investments. This investment strategy is designed with the construction of a final repository around 2130 in mind (COVRA, 2024). Since 2002, the State has been the sole shareholder of COVRA, represented by the Ministry of Finance (Rathenau Instituut, 2023b). The ministry must approve COVRA's investment strategy. Should returns fall short of expectations over the 100-year period, the State will need to cover the shortfall in funds.

Cooperation with other countries
The government expressed its support for multinational cooperation in the long-term management of radioactive waste as early as 1984 (VROM, 1984). This cooperation could involve sharing knowledge and developing an international repository. Such a facility may be of interest to countries with relatively little radioactive waste or those with less favourable geological conditions (IAEA, 2004, 2016). The Netherlands has participated in several international and European research projects and, since 2016, has officially pursuing a dual strategy (ministerie van Infrastructuur en Milieu, 2016). This means that while the Netherlands is planning for a national repository, it has not ruled out the option of collaborating on an international repository with other EU Member States.

The option of a multinational repository is mainly explored by national waste organisations within the European Repository Development Organisation (ERDO). ERDO facilitates knowledge exchange on national and multinational options for final disposal. Currently, eight organisations from seven European countries are members of ERDO. COVRA played a key role in the founding of ERDO in 2009. ERDO became an association in 2021, and COVRA hosts the secretariat. In December 2022, the Dutch and Belgian governments signed a declaration of intent to cooperate on nuclear energy and radioactive waste (Ministerie van Infrastructuur en Waterstaat, 2024).

Step-by-step and participatory decision-making
The approach to decision-making has evolved over the decades. In the 1970s, growing public resistance emerged against the government’s top-down decision-making (Rathenau Instituut, 2023b). Society increasingly demanded a role in decision-making on radioactive waste and nuclear power. In response, the government sought ways to enhance public involvement in the decision-making process. For example, citizens were able to voice their opinions on the disposal of radioactive waste during the Broad Public Debate on Dutch energy policy in the 1980s, and during the public consultation procedure surrounding environmental and waste policy in the 1990s (Rathenau Instituut, 2023b).

EU member states are legally required to involve the public in decision-making on radioactive waste management (2011/70/Euratom, 2011, art. 10). Like other EU countries, the Netherlands has opted for a more participatory and step-by-step approach (Ministerie van Infrastructuur en Milieu, 2016). The latter means that the decision-making process takes place in steps or phases that are reversible. This allows current or future generations to deviate from decisions on issues such as the disposal method (geological disposal) and the timeframe (realisation around 2130).

It is unclear how the government intends to establish the participatory and step-by-step decision-making process. This is why the State Secretary for Infrastructure and Water Management asked the Rathenau Instituut to provide advice on this matter. In addition, in late 2022, the State Secretary announced the intention to draw up a roadmap for a final repository (Brief van de Staatssecretaris, 2022a; Brief van de Staatssecretaris, 2022b). This roadmap will outline the necessary steps for developing and realizing a final repository, and what this requires in terms of decision-making, legislation, participation, knowledge, financing and multinational cooperation (Ministerie van Infrastructuur en Milieu, 2016).

1.3 The work ahead

Many decisions must be made before the Netherlands can reach a definitive solution for the long-term management of radioactive waste (Rathenau Instituut, 2023b). Below, we elaborate on the challenges and issues related to how the Netherlands organises decision-making, makes policy and legislation, organises participation and knowledge, and manages finances.

Organising decision-making
The Netherlands has yet to determine the specifics of the decision-making process for long-term radioactive waste management. Before the Netherlands has a definitive solution, it will need to make many decisions such as on the disposal method, siting issues, financing, possible cooperation with other countries, as well as what this entire process should look like and how the public will be involved. These decisions are interconnected and will be made by various parties at different times and places.

It is currently unclear what decisions need to be taken before 2100 in order to decide on a definitive solution. In addition, it is unclear how the Netherlands intends to implement its dual strategy. The Netherlands aims to explore both a national and multinational route towards a final repository, however, both routes require further elaboration. The roadmap announced by the Ministry of Infrastructure and Water Management should provide more clarity on this (Brief van de Staatssecretaris, 2022a; Brief van de Staatssecretaris, 2022b).

Several actors have criticised the lack of a decision-making strategy. According to the Netherlands Commission for Environmental Assessment, the 2016 *National Programme* misses opportunities to make decision-making measurable and to accelerate it (Commissie mer, 2015). The Netherlands Commission for Environmental Assessment is an independent advisory board that advises on the content and quality of environmental impact reports. Experts from the International

Atomic Energy Agency (IAEA) also expressed concerns about the lack of specific milestones beyond those set for 2100 and 2130. They argue that additional milestones are needed to build a legal framework, organise participation, conduct research and develop disposal concepts in a timely manner (ARTEMIS, 2024).

Policy and legislation

There are several challenges in the areas of policy and legislation. For example, experts and stakeholders disagree on whether or not the Netherlands has opted for a geological repository (Rathenau Instituut, 2024a). Some assume that the Netherlands established back in 1984 that the waste will go into a geological repository. Others think the Netherlands will not decide on this until around 2100 and that the choice for (an)other disposal method(s) is also still possible, such as a combination of deep geological disposal for high-level and long-lived waste and shallow disposal for low-level and intermediate-level waste. This could take place within the Netherlands or elsewhere, with or without international cooperation.

For clarity, it may help to lay down in legislation the management options and associated criteria for each waste category. This is currently not the case in the Netherlands. Moreover, the categories of radioactive waste in policy do not match the definitions in the law, leading to ambiguity (Rathenau Instituut, 2024c). Furthermore, according to the IAEA expert team these categories do not adequately address long-term management (ARTEMIS, 2024). As a result, the team sees a risk that some long-term management options may be more difficult to implement because the waste is not appropriately classified.

In addition, the four guiding policy principles are not adequately developed in policy and legislation. This means that they do not offer sufficient guidance for practical application and are of limited use for assessing disposal options (ARTEMIS, 2024; Commissie mer, 2024; Rathenau Instituut, 2024c). The findings from various evaluations include the following.

- **Minimising the generation of radioactive waste**. The government considers it important to limit the generation of radioactive waste, but has few tools to manage this (Oostdijk et al., 2022; RIVM, 2021). As a result, responsibility for minimisation lies mainly with waste producers.
- **Safe management of radioactive waste**. The regulations for the safe management of radioactive waste focus on current activities (ARTEMIS, 2024; Rathenau Instituut, 2024d). The law contains very few specific regulations for final disposal.
- **No unreasonable burdens on the shoulders of future generations**. The *National Programme* does not sufficiently clarify what steps are now needed to achieve safe management in the future (ARTEMIS, 2024; Oostdijk et al., 2022).

- **The causers of radioactive waste are responsible for the costs of its management.** It is not clear which costs should be covered by waste producers and which should be paid by the government (ARTEMIS, 2024; Rathenau Instituut, 2023a, 2024a; RIVM, 2021).

Should the Netherlands wish to implement a geological repository, the legal framework does not yet provide sufficient guidance to guide the decision-making process (Rathenau Instituut, 2024c). The fact that legislation on spatial planning and the environment do not specifically address the disposal of radioactive waste may, in the long run, create ambiguity about the responsibilities of different authorities and conflicts with other applications that use the subsurface, such as carbon dioxide storage and drinking water supply.

Organising public participation
The Netherlands has yet to determine how the public will be involved in decision-making on the long-term management of radioactive waste. According to international organisations such as the IAEA and the Nuclear Energy Agency (NEA), public participation should be an ongoing process that begins early when decisions are not yet finalized (IAEA, 2011b; NEA, 2003). Dutch experts and stakeholders emphasise that early participation allows for obtaining a timely overview of all interests and the knowledge needed, and for fostering shared responsibility (Rathenau Instituut, 2024a).

The government is eager to initiate participation in a timely manner, but is struggling to determine a suitable starting point (Ministerie van Infrastructuur en Milieu, 2016). This is mainly due to the lack of a decision-making plan. It is essential to clarify what the participation should lead to and what will happen with these results in the decision-making process. If participants do not understand what decisions being made, their willingness to participate will be limited (Rathenau Instituut, 2015). Dutch legislation also provides little guidance when it comes to early participation in decision-making on radioactive waste management (Rathenau Instituut, 2024c).

Organising knowledge
Knowledge is necessary to determine how and where the Netherlands can permanently dispose of its radioactive waste and how to organise decision-making on this issue (Rathenau Instituut, 2024b). Because little attention was paid to radioactive waste for many years, the Dutch government invested very little in knowledge building and expertise preservation (Dekker et al., 2023). Although it organised several temporary research programmes, these programmes were not sufficiently cohesive; resulting in a lack of continuity and the need to rebuild knowledge from scratch. Currently, without a clear plan for decision-making, it remains unclear to stakeholders and experts what knowledge and expertise is

needed at what times (Rathenau Instituut, 2024b). There are also insufficient structural resources. This hampers the development, collection and application of knowledge, as well as international research cooperation and integration of this knowledge in the Dutch context.

Moreover, knowledge development in the Netherlands is limited compared to other countries, and primarily focused on short-term needs (ARTEMIS, 2024). There are also concerns about the ageing workforce and lack of diversity in knowledge disciplines involved (Rathenau Instituut, 2024b). The focus is mainly on generating technical knowledge for developing a final repository, while other knowledge needed for decision-making is neglected. In addition, expertise on radioactive waste management is concentrated among a few organisations, such as COVRA, NRG and Delft University of Technology. This makes the Dutch knowledge position vulnerable. The loss of a party or several key employees would be difficult to absorb. There are also insufficient parties who can verify and supplement each other's knowledge.

Knowledge coordination across organisations, disciplines and domains is essential, but currently lacking (Rathenau Instituut, 2024b). Recent efforts to strengthen the knowledge infrastructure in the nuclear domain reinforce the position of established parties and mainly encourage the development of technical knowledge. For example, former Minister for Climate and Energy Policy Jetten announced that he would fund three chairs and six PhD positions at Delft University of Technology (Jetten, 2023). While this is a positive step, it is also a missed opportunity to involve multiple universities.

Organising finances

The Netherlands must secure sufficient financial resources for long-term radioactive waste management. These resources are needed for the management itself, but also for knowledge development and public involvement in decision-making. Currently, there is no cost estimate for the entire process leading to final disposal, including research, public participation, site selection and possible alternative disposal methods. Such an estimate is crucial for earmarking adequate resources and helps implementing the policy principle that the polluter pays.

In addition, COVRA's cost estimate for constructing a final repository lacks transparency and is difficult for outsiders to comprehend (Rathenau Instituut, 2023a). The ANVS Advisory Board and several experts and stakeholders have highlighted the issue of the absence of a regulatory framework for assessing the financing of the long-term management of radioactive waste (Raad van Advies ANVS, 2020; Rathenau Instituut, 2023a, 2024a).

Currently, COVRA utilises funds from waste producers to cover the cost of radioactive waste management. The Dutch government pays the costs related to decision-making and public participation. It is therefore unclear to stakeholders and experts how the polluter pays principle is being implemented in the Netherlands (Rathenau Instituut, 2024a).

1.4 Need for greater urgency and direction

Experts and stakeholders express appreciation, criticism and concerns about how the Netherlands is shaping radioactive waste management.

An IAEA expert team found that the Dutch policy meets current needs well (ARTEMIS, 2024). It praises the Ministry of Infrastructure and Water Management, ANVS and COVRA for their attention to safety, innovation and openness. Dutch experts and stakeholders recognise the benefits of the current above-ground storage for at least 100 years (Rathenau Instituut, 2023a). This storage gives the Netherlands time to save money, conduct research, and engage society in decision-making on the long-term management of radioactive waste. In addition, some anticipate that the Netherlands may be able to adopt better techniques for waste management in the future, or participate in an international final repository initiative.

At the same time, there are significant criticisms. Experts and stakeholders argue that more urgency and direction are needed, and that decisions should be made earlier than 2100. For example, the European Commission raised concerns about whether the government is taking adequate steps to alleviate the burden on future generations (Rathenau Instituut, 2023b). In response to this question, the Ministry of Infrastructure and Water Management referred to the advantages of the timeframe as mentioned above (Brief van de minister van Infrastructuur en Milieu, 2017). However, the IAEA expert team believes that simply mentioning these benefits is insufficient (ARTEMIS, 2024). They argue that a critical assessment of risks is needed to avoid passing the burden on to future generations. Such an assessment is currently lacking.

Several experts and stakeholders feel that the policy to decide in around the year 2100 contributes to a lack of social and political urgency to start working on long-term management (Rathenau Instituut, 2023a, 2024a, 2024b). This is a key reason why there is little political and public debate on this issue. The long time horizon of 100 years does not sufficiently compel administrators to address the issue now (Adviesgroep OPERA, 2017). As a result, there is a risk of shifting responsibility onto future generations. The long time horizon also weakens the sense of urgency

among citizens on this issue (Rathenau Instituut, 2015). If no action is to be taken until 80 years' time, they see little reason to be involved in public participation now.

Another concern is that by the year 2100 finding a suitable disposal site may be much more difficult than it is today (Rathenau Instituut, 2023a). Several stakeholders, including provincial officers, see an increased use of the subsurface and fear that most suitable locations will already be occupied by 2100. The Netherlands Commission for Environmental Assessment also warns of this risk and recommends reserving locations sooner (Commissie mer, 2015). Although the government included this as an action point in the previous *National Programme*, it received no follow up (Ministerie van Infrastructuur en Milieu, 2016). The ANVS Advisory Board also proposed to bring forward the decision-making process on the disposal method and the location (Raad van Advies ANVS, 2020). Experiences in other European countries show that geological research and the site selection process can take many decades (Arentsen & Van Est, 2023).

Most of the other EU Member States want to build a final repository over 60 years earlier than the Netherlands (see Figure 4). The further the Netherlands lags behind in terms of decision-making, participation and knowledge, the harder it will be to join international initiatives. Several experts and stakeholders fear that this will make the Netherlands less attractive as a cooperation partner (Rathenau Instituut, 2023a).

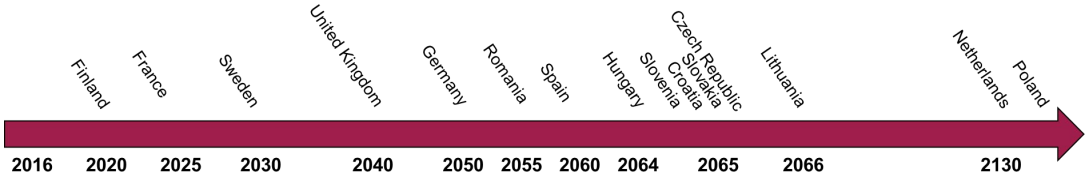

Figure 4 Year when EU Member States expect to have their final repository ready (Europese Commissie, 2019, p. 10).

Radioactive waste is not only generated during the production of nuclear energy, but is nevertheless mainly associated with it in public and political discussions (Rathenau Instituut, 2015). After all, more nuclear energy production will lead to more high-level waste. With the government's plans for new nuclear power plants, several stakeholders want greater clarity on the storage and disposal of radioactive waste (Rathenau Instituut, 2023a). Among other things, they question whether the storage capacity at COVRA is still sufficient and whether it is possible and desirable to use different disposal methods for different types of waste.

Some argue that the Netherlands should make an earlier decision on the long-term management of radioactive waste given its nuclear ambitions. Residents of Borsele

stipulate this as one of the conditions for the construction of a new nuclear power plant in their municipality, advocating for a final repository to be established by 2050 (De Borselse Voorwaarden Groep, 2023). At present, however, it remains unclear how the waste issue will influence deliberations on the building of new nuclear power plants (Rathenau Instituut, 2023a). The Netherlands Commission for Environmental Assessment sees the risk that the government will take a decision on nuclear energy without adequately considering the implications for radioactive waste management (Commissie mer, 2024).

1.5 Taking steps together

The analysis above indicates that experts and stakeholders perceive a lack of urgency in decision-making on the long-term management of radioactive waste, particularly due to the long time scale until 2100. The uncertainty about the steps the government intends to take before then creates a need for more direction. The Rathenau Instituut concludes that waiting until around 2100 to make decisions is undesirable, as there is work to be done now. To avoid missing opportunities and passing unnecessary burden onto future generations, the government needs to provide more direction and urgency. This will also create the clarity needed on the management of radioactive waste given the government's nuclear ambitions. The question is how the Netherlands can best address this.

In many countries, decision-making on radioactive waste disposal has been a process of trial and error (Arentsen & Van Est, 2023; NEA, 2004). Finding a viable solution often takes longer than expected and sometimes goes differently than planned. This is because radioactive waste management is not just a technical, but also a political and societal issue. In addition, this process has never been carried out in the Netherlands before, increasing the likelihood of necessary adjustments along the way. Given that decision-making takes several decades, it is difficult to predict how technology and society will evolve over that period and how those developments will in turn affect decision-making.

To navigate such challenges and uncertainties, many countries adopt a step-by-step and participatory decision-making process (NEA, 2004). This involves breaking down the process towards a final repository into a series of smaller steps and milestones, with the involvement of politicians and society. Milestones are points in time when a major decision is taken, usually by the national government or parliament (IAEA, 2023). Such an approach provides both long- and short-term direction and focus. If done well, taking steps together contributes to legitimacy and stability.

Step-by-step decision-making is not just about achieving milestones. The process must also facilitate collaborative learning by doing. This requires a robust institutional and organisational setting in which decisions are taken and participation, knowledge and finance are organised. This governance ecosystem must foster conditions that enable the integration of different perspectives and uncertainties, identify any errors and arrive at solutions that gain broad public support (Arentsen & Van Est, 2023; National Research Council, 2003; Parotte, 2020).

While the Dutch government intends to establish a step-by-step decision-making process, it has not not yet started doing so. The following chapters outline what such a step-by-step and participatory decision-making process could look like for the Netherlands. Chapter 2 presents a step-by-step, participatory approach based on four recommendations. One recommendation is to establish at the beginning of each step in the decision-making process how decision-making, public participation, knowledge and financing will be organised during that step. Chapter 3 further elaborates on this and provides recommendations and action points to put the organisation of decision-making, participation, knowledge and financing into practice.

2 Recommendations for step-by-step and participatory decision-making

The aim of a step-by-step, participatory decision-making approach is to democratically and effectively develop a solution for the long-term management of radioactive waste that enjoys broad public support. Although the government has indicated its intentions to establish such a process, it has not yet specified how it wants to do that. This chapter proposes a framework for that process based on four recommendations.

Other countries have already adopted a step-by-step and participatory approach to decision-making on the long-term management of their radioactive waste (NEA, 2004). How different countries shape this depends on factors such as their political culture, social norms and values, and their history with radioactive waste management (Arentsen & Van Est, 2023). The experiences of these countries offer inspiration and examples, but not a comprehensive blueprint for the Netherlands. Moreover, decision-making is still ongoing in many countries, making it impossible to evaluate the entire process and draw lessons from it at this stage.

International organisations such as the IAEA have developed generic roadmaps for achieving geological disposal repositories (IAEA, 2023a). The question is whether these are useful for the Netherlands. After all, a key principle of Dutch policy is that decision-making is reversible so that future generations have the opportunity to choose their own management method (ministerie van Infrastructuur en Milieu, 2016). This is likely to be more difficult if the process is already set up around a single prescribed pathway to a geological repository (Koning Boudewijnstichting, 2024b; National Research Council, 2003).

The Rathenau Instituut therefore proposes a step-by-step, participatory decision-making process that aligns with the government's intention to develop a roadmap for the final disposal of radioactive waste. But instead of plotting a single route to a geological repository, the Rathenau Instituut recommends exploring different disposal methods, and thus different routes, in conjunction with each other. This approach allows decision-making to start immediately without compromising the freedom of choice of future generations.

Below, we elaborate on that approach through four recommendations, which we explain in more detail in the following paragraphs.

1. Establish a participatory, step-by-step approach now.
2. Determine through a participatory process which disposal options the Netherlands wants to explore and develop further.
3. Divide the decision-making process into five phases: the initiation phase, the development and siting phase, the construction and operation phase, the closure phase and the post-closure phase.
4. Organise decision-making, public participation, knowledge and financing at each step.

2.1 Establish a participatory, step-by-step approach now

While the government wants a step-by-step and participatory approach to decision-making, it has yet to act on this. Current policy aims at a decision around 2100, without clarifying what interim steps are needed. A step-by-step approach requires a different method than setting an end goal and reasoning backwards, as the government currently proposes by solely developing a roadmap for a final repository within that timeframe.

The Rathenau Instituut advises the government to include a participatory, step-by-step approach to decision-making in the 2025 *National Programme*. Consequently, the year 2100 would be abandoned as the moment to decide on a definitive disposal method. This does not imply that a final repository needs to be constructed in the short term or that there is any need to rush, but that decisions on the timeframe for the step-by-step approach should be made in a participatory way.

The decision-making phases outlined in this chapter (recommendation 3) can serve as a basis for this approach. This means that in the *National Programme*, the government is already outlining the phases without detailing every aspect. Experts and stakeholders emphasise the importance of a long-term perspective, while also advocating for interim evaluations and adjustments to adapt to changes and include future generations in the process (Rathenau Instituut, 2023a, 2024a).

The Rathenau Instituut recommends starting the first phase immediately after the *National Programme* is adopted in 2025. Preparing for that phase and the steps involved, will make it possible to enter discussions on clearly defined topics, which will provide focus and direction to decision-making. By attaching clear deadlines to each step, the process gains more sense of urgency, moving it away from the

distant 2100 timeframe. Instead, the process consists of a series of incremental decisions, some of which need to be made in the short term.

2.2 Determine through a participatory process which disposal options the Netherlands wants to explore further

The government's roadmap aims to establish a deep geological repository (Brief van de Staatssecretaris, 2022a; Brief van de Staatssecretaris, 2022b). This raises the question how much room there is for alternative disposal methods and what role they will have in the decision-making process. Alternative options include deep boreholes, above ground storage and near surface disposal (see Figure 2). Stakeholders and experts place a lot of emphasis on exploring alternatives (Rathenau Instituut, 2024a). The Dutch Commission for Environmental Assessment has also recommended developing alternative roadmaps to allow for a more thorough consideration of the pros and cons of the various options (Commissie mer, 2024).

There are several reasons to consider multiple disposal methods beyond deep geological disposal. A number of stakeholders and experts argue that having alternatives available is useful in case a geological repository in the Netherlands proves unfeasible or undesirable (Rathenau Instituut, 2024a). In addition, advancements in disposal methods may emerge over time. The Netherlands also follows a dual strategy, which means that a multinational repository is also an option. If the Netherlands successfully pursues its current nuclear ambitions, it may become economically more attractive to adopt different disposal methods for various types of waste instead of placing all waste in a geological repository. Belgium and France, for example, are already opting to place low-level and intermediate-level waste in surface repositories while reserving deep geological repositories for high-level waste.

Exploring different management options allows society to be involved in decision-making at a time when choices are still open, as recommended by international organisations (IAEA, 2022; NEA, 2004). Engaging society in this way enhances the transparency and legitimacy of decision-making. Involved actors gain more insight into how choices are made and can actively influence these choices. Dutch experts and stakeholders emphasise that participation can help prevent tunnel vision among experts (Rathenau Instituut, 2024a). They think it is important that the management method is not chosen solely on the basis of technical criteria.

In the light of this, the Rathenau Instituut recommends the government to explore routes for multiple disposal methods, including a geological repository. Since it is not possible to explore and develop all options to the same extent, the Rathenau Instituut recommends drawing up a disposal programme that identifies a number of options for further exploration (see Box 1 and Figure 5). By doing so, the government can rule out other options. Any chosen option must be adequately resourced and budgeted. At periodic evaluation points, the government may decide to cease further development of options that turn out not to be feasible or desirable after all, or add new options to develop.

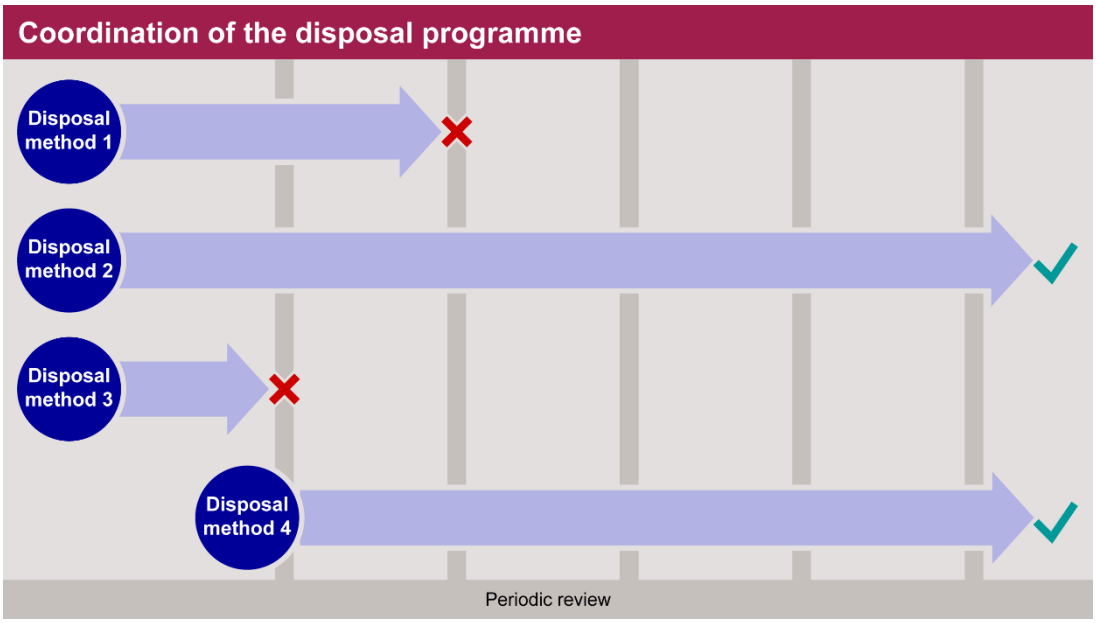

Figure 5 Schematic representation of a disposal programme with different roadmaps.

In addition, the Rathenau Instituut advises the government to engage society in determining which disposal options will be researched and developed. The 2025 *National Programme* can already identify a number of disposal options for further exploration. It is crucial for the government to establish a disposal programme in good consultation with various groups in society to ensure broad public support. This can be done on the basis of a similar exploration of different disposal options, as was conducted in preparation for the 2016 *National Programme* (ARCADIS & Ministry of Economic Affairs, 2014). A new exploratory study is needed to reflect the most recent state of affairs, especially since the earlier assessment assumed the Netherlands would cease nuclear energy production in the short term.

Clarifying dual strategy

When drawing up a disposal programme, the dual strategy can be further developed. Several options or roadmaps are also possible for multinational disposal

(IAEA, 2004). For example, countries can either open their national repositories to waste from other countries, subject to conditions, or collaboratively build a disposal facility. The Rathenau Instituut recommends that the disposal programme should clarify which multinational roadmaps the Netherlands wants to explore, and that the opportunities for multinational cooperation should also be considered when elaborating the national management options (see Box 1).

Box 1 A disposal programme for the long-term management of radioactive waste

The purpose of a disposal programme is to decide on one or more management methods for the long-term management of radioactive waste. This could include a geological repository, near surface disposal or deep boreholes, organised at national level or in cooperation with other countries. This box addresses four key elements of such a programme (see Figure 5):

- creating roadmaps
- prioritising options
- elaborating on the dual strategy, and
- coordinating and evaluating the disposal programme.

Creating roadmaps

For each disposal option to be explored, a disposal programme includes a roadmap that clarifies how decision-making, knowledge, public participation and financing will be organised for that option. It is important that the choices made within a certain roadmap are made as explicit as possible (see also Commissie mer, 2024). Those choices include:

- technical design capabilities
- minimum and maximum storage and/or disposal capacity
- types of radioactive waste for which the option is suitable
- suitability for import or export of waste
- location and/or reservation of possible sites
- possible steps in the decision-making process; and
- specification of knowledge requirements for each step.

Information about these choices helps in the further development of a certain disposal method, and that within the overarching decision-making process the pros and cons of disposal options can be assessed. After all, each of these choices have advantages and disadvantages that require careful consideration.

Prioritising options

Since it is neither possible nor desirable to explore every option to the same extent, the government will need to prioritise the disposal options. This can be done by allocating resources and reaching agreements on how long alternatives will be explored. It is likely that more resources will be set aside here for exploring and developing a geological repository, as current scientific consensus indicates this is the most appropriate long-term disposal option (Ministerie van Infrastructuur en Milieu, 2016). In addition, exploring some disposal methods in cooperation with other countries may provide benefits in terms of expertise and costs (Rathenau Instituut, 2024a, 2024b).

Elaborating on the dual strategy

When drawing up the roadmaps, the dual strategy needs to play a role in two ways. First, the suitability of each disposal option for importing waste from other countries can be assessed. Some countries, for example, open their repositories to waste from other countries. For instance, Belgium has agreed to open its disposal facilities to Luxembourg, which produces little radioactive waste (Overeenkomst tussen het Koninkrijk België en het Groothertogdom Luxemburg, 2019).

Second, the government may also decide to include a separate roadmap for jointly exploring disposal options with several countries. This could take different forms: a joint final repository in a host country, or several management facilities for specific types of waste, possibly spread across different countries (IAEA, 2004). The disposal programme should clarify which multinational routes the Netherlands wants to explore. A dedicated roadmap for a joint multinational repository is desirable because the construction of such a facility involves numerous challenges in areas such as participation, financing, legislation and site selection (IAEA, 2016; Rathenau Instituut, 2023a).

Coordinating and evaluating the disposal programme

A disposal programme consists of several roadmaps with their own timelines and schedules. It is important that the government coordinates this programme and takes stock at periodic intervals by evaluating and making adjustments if necessary. This might involve allocating more or less resources, ceasing exploration of certain options, or considering new options. Another key factor to consider is how disposal methods might complement each other. It is also important to look at the expected quantities of waste and possible shifts in these quantities, and anticipate these shifts. The Rathenau Instituut therefore recommends periodic adjustments to the process in two ways: at set evaluation moments and at specific milestones.

The ten-yearly review of the *National Programme* and the three-yearly report on its progress to the European Commission can serve as fixed evaluation moments. These are times at which the government needs to reflect on the decision-making process, disposal programme, waste inventory and cost estimate for long-term management. It can then also make a comparison of the various disposal methods and decide which to pursue further, which to discontinue, and which new options merit exploration.

In addition, the government may organise reviews around specific milestones, when the national government or parliament is expected to take important decisions (IAEA, 2023b, pp. 11-12). Examples of milestones include: the adoption of a disposal programme, establishing a process for site selection, choosing of research and disposal sites, and licensing for construction, use and closure of a repository. These decisions require a review of all available knowledge and input from experts and stakeholders. This helps not only to complete a step, but also to determine what the next steps look like.

2.3 Divide the decision-making process into five phases

International organisations such as the IAEA (2023b) and the European research programme EURAD (2021) recommend specific phases for constructing a geological repository. The adoption of a disposal programme is typically followed by several phases for identifying suitable sites, construction, commissioning and closure of the geological repository. However, the Rathenau Instituut advices to explore additional disposal methods beyond a geological repository and emphasises the importance of societal involvement. This necessitates some adjustments to the regular phases.

The Rathenau Instituut recommends dividing the participatory and step-by-step approach to decision-making into five phases. These are as follows:

1. initiation phase
2. development and siting phase
3. construction and operation phase
4. closure phase, and
5. post-closure phase.

These five phases largely correspond to the IAEA and EURAD phases. A key difference is that in the initiation phase, a disposal programme is established that consists of multiple disposal options (see recommendation 2, Figure 5). Each disposal option has its own decision-making process and roadmap (see Box 1). This means that phases 2 to 5 will be executed separately for each disposal method within the disposal programme. Not every disposal method will go through all the phases. If a particular disposal option proves unfeasible or undesirable, this roadmap may be discontinued.

The phased approach provides insight into how step-by-step, participatory decision-making unfolds over time. Such structuring is essential for making progress, maintain flexibility, measuring outcomes, and anticipate future decisions. It is important to stress that the decision-making process may not adhere strictly to this timeline (IAEA, 2023b). Experience in other countries shows that some phases take longer than expected and sometimes a different approach is required to move forward. The evaluation moments from Box 1 can be used to adjust the roadmaps (review and progress reports for the *National Programme* and major decisions).

Figure 6 outlines the steps and milestones associated with each phase. At the start of each phase, the government will determine through a participatory process what exactly that phase will look like, including the steps to take and the expected outcomes. This presents an opportunity to learn from previous experiences and look ahead with the knowledge available at that time. The descriptions below offer an indication of how the process can unfold, with the understanding that this can be further detailed or modified as needed.

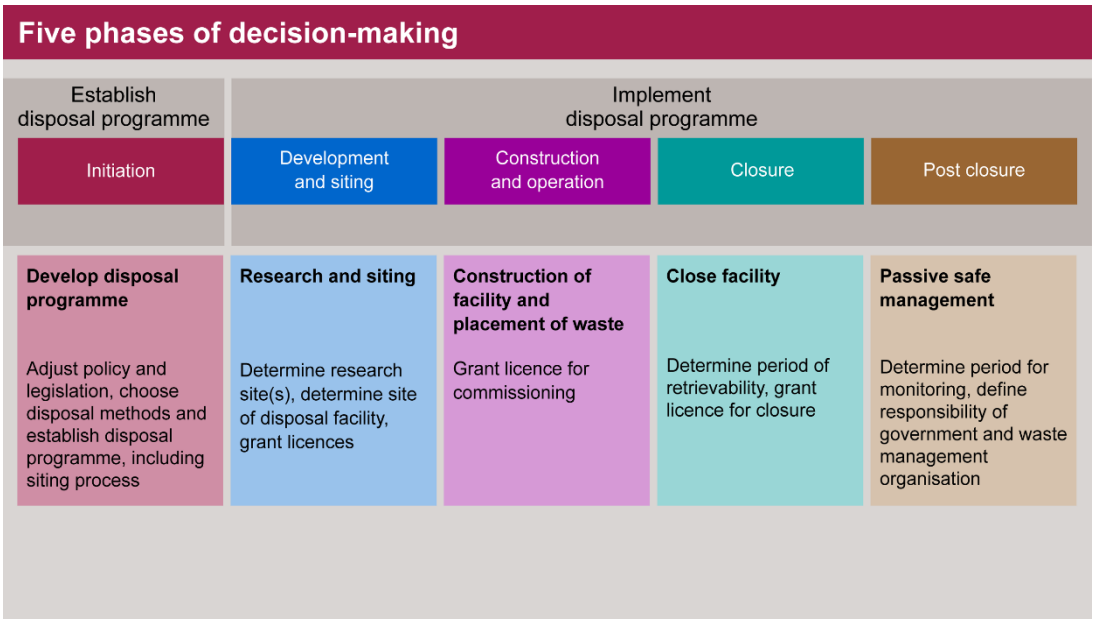

Figure 6 Schematic representation of the phases, goals and relevant decisions for a disposal programme.

Initiation phase
The aim of the initiation phase is to establish a disposal programme that enjoys broad public and political support. This phase can commence after the adoption of the 2025 *National Programme* and is estimated to last five to ten years. This timeframe will allow time to research and assess various disposal methods, prepare roadmaps and organise public consultation.

The initiation phase consists of at least the following activities:

- establishing a participatory process for assessing and choosing disposal methods
- updating policies and legislation to assess disposal methods
- participatory assessment and selection of disposal methods
- preparing roadmaps for the different disposal methods
- establishing a disposal programme, including roadmaps and
- drafting policies and/or legislation to implement the disposal programme.

Before developing the roadmaps, it is important to clarify the process for doing so. This for example necessitates updating policies and legislation. As described in Chapter 1, certain underlying principles for the long-term management of radioactive waste are not yet sufficiently developed and the current classification focuses more on storage rather than final disposal. This makes it difficult to explore and test different disposal methods against these principles. In addition, the advantages and disadvantages of different disposal methods and choices need to be discussed to determine which may be suitable for the Netherlands (see Box 1).

The government then determines for which disposal options a roadmap will be drawn up. This is an important milestone in this phase. In order to implement the disposal programme, further adjustments in policies and legislation may be needed. It is also essential to ensure that sufficient capacity and resources are available for all components of the disposal programme. In addition, there might be a need to redefine roles and responsibilities, or set up new institutions.

Development and siting phase
The development and siting phase marks the beginning of the disposal program’s implementation. When a specific disposal option is successfully developed, this phase moves step by step towards a suitable site for its realisation. The government may also decide to stop exploring a disposal option. The licence application for the construction of a facility can be a milestone in this phase. The same applies to a decision to stop developing a disposal option.

Several steps must be taken before a disposal method can be realised. For example, at some point it is necessary to look for a suitable location. Depending on the disposal method, this search process may consist of several steps. It is important to establish clear procedures for this in a participatory way, ensuring that all stakeholders understand how the site selection is made and what roles and responsibilities they have in this (Kuppler & Hocke, 2018).

Experiences with researching and developing a geological repository in the Netherlands and elsewhere show that on-site research, such as for exploratory drilling, is a sensitive social and political process (Arentsen & Van Est, 2023). For example, the announcement by the Dutch government of exploratory drilling in the 1970s led to significant protests in the north-eastern Netherlands (Rathenau Instituut, 2023b). Therefore, research, participation and the site selection process must be integrated in this phase.

A geological repository may also require investigation through an underground research laboratory, to demonstrate the suitability of a particular geological layer for a repository. In a next step, the search for a suitable site for the repository can commence. The construction of a laboratory and the eventual construction of the final disposal facility require several licences, which are in turn subject to participation requirements (for an overview see: Rathenau Instituut, 2024d). The regulator, currently the ANVS, will review these licences.

Given the complexity and social sensitivity of the steps involved, decision-making regarding a site for a final repository could take several decades. Finland has been the fastest country so far to complete the process of identifying a location and constructing a geological final repository, taking around 40 years (Vehmas et al., 2023). The development and siting phase for other disposal options may be less complex than those for geological disposal. Determining a location for near surface disposal, for example, does not require exploratory drilling and an underground laboratory.

The nature of decision-making, and the role of public participation in this process, is different in the development and siting phase than in the initiation phase. During the initiation phase, decision-making and public participation take place at the national level, while the development and siting phase has a stronger local character. It is therefore important to coordinate and align participation at national and local levels.

Construction and operation phase

The construction and operation phase starts after the approval of the licence application to implement a disposal option. This phase focuses on the construction

of a disposal facility, and once found safe, placement of the waste in this facility. Upon completion of a disposal facility, a licence must be granted for its commissioning.

Some countries, including France, opt for a trial period before the waste can actually be placed in the disposal facility (Lehtonen, 2023). This approach is also recommended by international organisations (IAEA, 2011a; National Research Council, 2003).

In the case of a multinational repository, clarifying legal ownership of the waste during this phase is crucial. It must be determined if the host country becomes the legal owner of the waste and whether the partner country remains liable for any issues that arise, and if so, for what duration (Rathenau Instituut, 2024d).

Depending on the type of disposal method and type of waste, the construction and operation phase can take several decades. For example, the OPERA research programme anticipated a 10-year design and construction phase for a geological repository and a 30-year period for filling it (Verhoef et al., 2017). Some of the high-level waste requires a cooling-off period before it can be placed in a final repository, which most countries estimate to be several decades long (NEA, 1989).

As in the previous phase, several disposal options may go through this phase. In addition, it is possible that the Netherlands will develop and operate one or more multinational solutions with other countries during this phase.

Closure phase
The closure phase applies to disposal methods such as geological disposal, near surface disposal and deep boreholes. This phase requires agreement on the period of retrievability, closure methods, and any decommissioning of the waste placement facility. These are national issues that need to be coordinated with local communities. It is important to build on previously set criteria and agreements made. These form the basis for the licence application for closure to the regulator. This is an important milestone.

Post-closure phase
The post-closure phase follows the closure of the disposal facility. The phase centres around passive safe management and no more efforts are needed to maintain safety. However, the decision may be made to monitor the facility's environment for a certain period. Agreements can also be made about how the site should be delivered. In addition, the government must make agreements about how the existence of the facility will be communicated to future generations, for example through landscape markers. With the closure of the disposal facility, the waste

manager can transfer management responsibility to the government (IAEA, 2023b). It is important that this is properly regulated by law (Rathenau Instituut, 2024d).

2.4 Organise decision-making, knowledge, participation and finance in each phase

The Rathenau Instituut advises the government to determine at the outset of each phase how decision-making, knowledge, public participation and finance will be organised. These four processes are essential for substantiating and legitimising decisions and ensuring that adequate resources are made available. The European Directive 2011/70/Euratom imposes legal obligations on Member States to ensure that these four processes are organised properly (2011/70/Euratom). The next chapter takes a more in-depth look at how these processes can be organised for the long-term management of radioactive waste. The following should always guide the organisation of these processes.

At the beginning of each phase, the government should engage experts and stakeholders about what these processes will look like. By involving a broad audience, a process can be created that takes into account the interests of different groups in society. Dutch experts and stakeholders also emphasise the importance of participation in shaping the decision-making process (Rathenau Instituut, 2024a). They believe this helps generate support for the decision-making process, which as a result will become more transparent.

In addition, the Rathenau Instituut recommends to anchor the approach to these processes in policy and legislation to ensure commitment from both the government and parliament. Experts and stakeholders consider it important to regularly involve parliament to legitimise decision-making (Rathenau Instituut, 2024a). At the same time, they argue that the government should avoid to legislate too much, as the decision-making process may evolve in unforeseen ways. Legislation should therefore provide sufficient flexibility for learning, experimentation, and adaptation of existing practices.

Other countries have used legislation to clarify next steps, delineate roles and responsibilities, and establish guiding principles for decision-making (Arentsen & Van Est, 2023). This provides certainty to the parties involved in radioactive waste management and helps to monitor the progress and quality of the process. Legislation can also protect the rights of various parties, including the general public and decentralised authorities.

There are no uniform procedures for organising decision-making, knowledge, participation and finance. Each phase and step in the decision-making process makes different demands on how these processes should be organised. The Rathenau Instituut therefore recommends conducting evaluations at the start of each phase to assess what is working well and identify what could be improved in the process organisation. It is important that evaluation and learning go hand in hand.

3 Organising decision-making, participation, knowledge and finance

This chapter elaborates on the fourth recommendation from the previous chapter to organise decision-making, knowledge, participation and finance in each phase (see Figure 7). Experience from other EU Member States show that these four processes need to be designed in such a way that they reinforce each other (Arentsen & Van Est, 2023). The recommendations in this chapter address both substantive and procedural choices, along with the corresponding allocation of tasks and responsibilities. It demonstrates how these four processes can contribute to effective and democratic decision-making to generate trust in the decision-making process and secure broad public support for the chosen solutions. For the initiation phase, which commences immediately after the adoption of the 2025 *National Programme*, this chapter contains specific action points for each process. We make a distinction between actions at the beginning and in the implementation of the initiation phase.

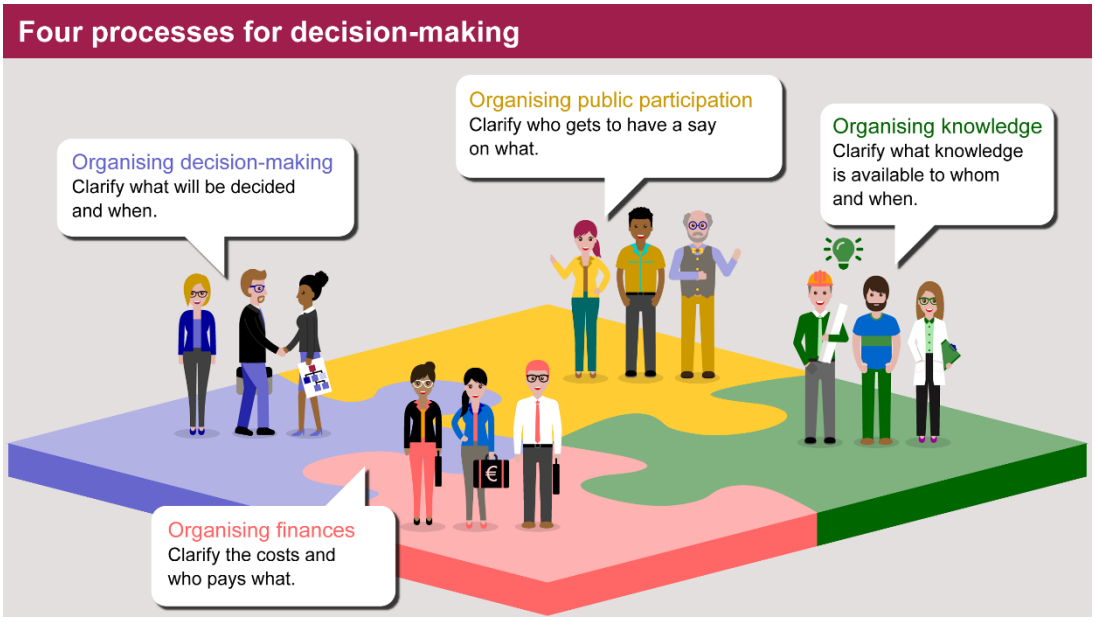

Figure 7 Four processes for decision-making

3.1 Organising decision-making

Organising decision-making is a process in itself, and involves establishing agreements on goals, steps, associated procedures, and roles and responsibilities. These agreements clarify how decisions on the long-term management of radioactive waste are made, ensuring stakeholders understand what to expect, their rights and obligations, and who can be held accountable if necessary. Making such agreements can enhance support for decision-making. When stakeholders agree on the decision-making process framework in advance, they are more likely to want to cooperate and accept the outcomes (Ferraro & Martell, 2015).

Decision-making is organised by agreeing on goals, principles, procedures, roles and responsibilities for each phase. To this end, the Rathenau Instituut makes three key recommendations:

- clearly articulate what the decision-making is about;
- develop clear procedures; and
- clarify and allocate roles and responsibilities for organising decision-making.

We elaborate on these recommendations below. Figure 8 summarises the recommendations and associated action points.

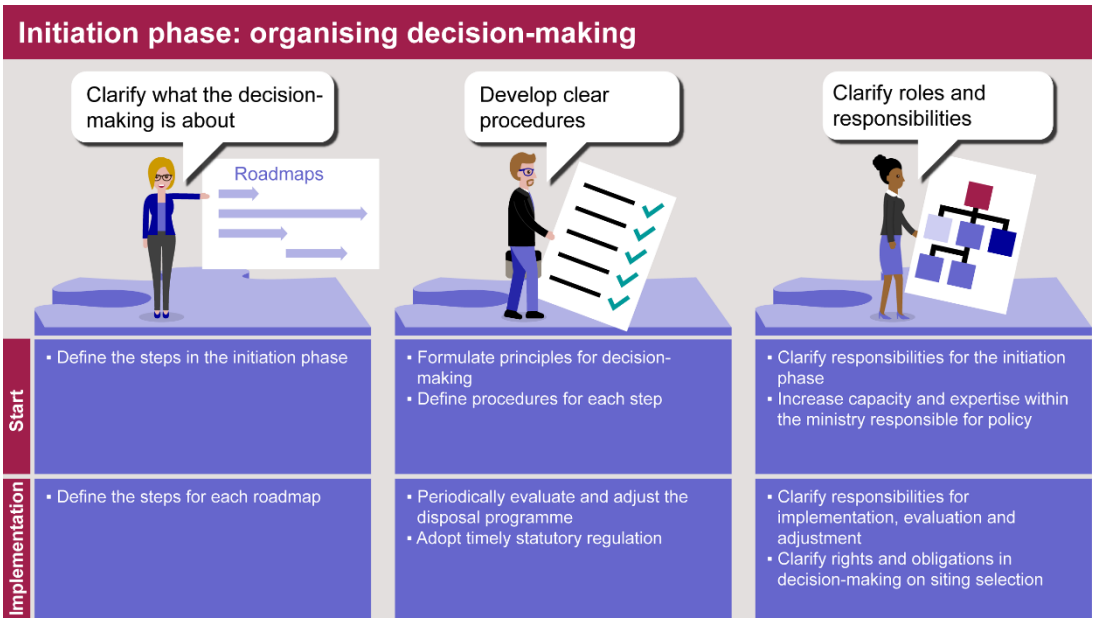

Figure 8 Overview of recommendations and action points for organising decision-making during the initiation phase

3.1.1 Clarity about what the decision-making is about

The Rathenau Instituut advices to clarify what the decision-making is and is not about. The government can do this by formulating specific goals and principles for each phase or step. This approach makes clear which choices have already been made and which remain open for discussion. Defining the scope of decisions creates focus and makes decision-making transparent. At the same time, it is important to show how various decisions are interrelated. For example, decentralised authorities want to know whether participating in research into a geological repository means that a repository will actually be built in their province or municipality. They need this information to carefully consider their position.

Action point for the beginning of the initiation phase
Outline the specific steps involved in the initiation phase.
The goal of the initiation phase is to establish a disposal programme that has broad public and political support. It is the government's role to clarify what steps precede this. It can build upon the activities described in the previous chapter, such as creating a process for assessing and selecting disposal methods, updating policies and developing roadmaps.

The Rathenau Instituut recommends setting up a process to determine, in consultation with the scientific community, waste producers, politicians and society, which waste management methods the Netherlands wants to research and further develop. Another important step is to clarify and elaborate the principles of the policy, as many principles are inadequately defined in current policy and legislation. This makes it difficult to implement and evaluate the principles, for example when drawing up environmental impact assessments (Netherlands Commission for Environmental Assessment, 2024).

Action point for implementing the initiation phase
Clarify what steps the roadmaps consist of.
Once the government has determined which disposal methods require roadmaps, the government, in consultation with experts and stakeholders, can outline the decision-making steps for each roadmap. Each roadmap should always work step-by-step towards decisions on the choices for a disposal method, such as: the technical design, the minimum and maximum capacity, the types of radioactive waste for which an option is suitable, cooperation with other countries and the timeframe for decision-making on aspects such as reserving and selecting sites (see also Box 1).

3.1.2 Clear procedures

Procedures determine how decisions are made, what steps are taken and who has what rights and obligations in this process. The Rathenau Instituut recommends that at the outset of each phase, the government clearly outlines what decisions will be made and which procedures will apply. These can be existing procedures, but also new ones. For instance, the Netherlands has not yet established a process to select a site for disposal facility. Existing procedures prescribe which licences are needed to build a disposal facility, but not how the government can chose between multiple potentially suitable locations (Rathenau Instituut, 2024e). It is important to make sound agreements in advance and to anchor them in policy and legislation, ensuring that stakeholders understand their positions and can have confidence in the process and the resulting choices.

Action points for the beginning of the initiation phase
Formulate principles for decision-making on long-term radioactive waste management.
The Rathenau Instituut recommends the government to explicitly define and elaborate on the principles for decision-making on the long-term management of radioactive waste at the beginning of the initiation phase and consult experts and stakeholders on this. These principles need to guide the decision-making process and make it possible to evaluate its quality.

The government wants decision-making on long-term radioactive waste management to be participatory, step-by-step and reversible, but does not specify how this will be implemented (Ministry of Infrastructure and Environment, 2016). Germany, Belgium and the UK have also formulated principles for decision-making, such as: flexible, step-by-step, transparent, participatory, scientific, self-critical, learning and resilient (Arentsen & Van Est, 2023). Dutch experts and stakeholders consider similar principles important (Rathenau Instituut, 2024a).

Identify which steps require new procedures.
Once the steps for the initiation phase are defined, the government needs to determine whether existing procedures can be utilised or if new ones must be developed. To establish the disposal programme, the government can partly use existing procedures. For example, the *National Programme* lists which solutions the Netherlands is investigating for the long-term management of radioactive waste. The Rathenau Instituut recommends including the disposal programme in the *National Programme*, so that the existing procedures for drafting the *National Programme* also apply to the disposal programme. In addition, during the implementation of the initiation phase, procedures should be drawn up for the site

selection process (see later under the action point: *Clarify who has what rights and obligations when deciding on the location for a specific disposal method*).

Action points for implementing the initiation phase
Establish a participatory process for periodic evaluation and adjustment of the disposal programme.
The Rathenau Instituut recommends that, when setting up the disposal programme, the government should determine the procedures through which the disposal programme will be evaluated and adjusted. This should include clarifying what criteria will be used to assess waste management options and how scientists, businesses, civil society organisations and citizens will be involved.

Adopt a statutory regulation in a timely fashion.
The Rathenau Instituut recommends the timely adoption of a statutory regulation for the long-term management of radioactive waste. This could be a new regulation or an extension of an existing regulation (Rathenau Instituut, 2024d). In this regulation, the government can specify how each category of waste will be managed now and in the future. In addition, the regulation can outline more specific rules on the decision-making process, the site selection process and the associated principles, including public participation and requirements in relation to retrievability and safety. Such regulation would provide stakeholders with more guidance than the *National Programme*. The Rathenau Instituut recommends that, if necessary, rules should also be drawn up for a multinational repository (Rathenau Instituut, 2024d).

3.1.3 Clear roles and responsibilities for organising decision-making

The Rathenau Instituut recommends clearly allocating roles and responsibilities for organising decision-making, to ensure that tasks are well-defined, continuity is maintained, accountability is established, and to have a good balance between power and counterpower (Arentsen & Van Est, 2023; Rathenau Instituut, 2024a). This means, among other things, that potentially conflicting interests are distributed among different organisations, there is proper oversight of the waste management organisation's tasks, important decisions are debated in parliament, and the negotiation position of citizens, civil society organisations and decentralised authorities is strengthened by assigning them clear rights and obligations.

Action points for the beginning of the initiation phase
Clarify who is responsible for the steps to be taken in the initiation phase.
The Rathenau Instituut advises the government to clearly define who is responsible for implementing activities during the initiation phase. While the government

ultimately bears responsibility, it can seek support from an existing or new organisation, as happens in other countries. The UK, for example, has a Committee on Radioactive Waste Management (CoRWM). In France, the Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST) played an important role in the initiation phase.

Experts and stakeholders see advantages in such a separate advisory committee for the initiation phase (Rathenau Instituut, 2024a), though subject to conditions. For example, the committee must be a neutral party with broad knowledge on technical aspects, decision-making and participation. The committee must also be financially and politically independent and have sufficient freedom to advise independently and communicate openly about this advice. There needs to be a broad consensus on the composition of the committee. To ensure its impact, clear rules are important, including a clear mandate and timeline and involvement of government and parliament.

Ensure sufficient capacity and expertise in the responsible ministry.
The government has primary responsibility for organising the initiation phase, which involves considerable effort not only to organise decision-making, but also to organise participation, knowledge and finance. The Rathenau Instituut advises the government to invest in sufficient capacity and expertise within the ministry responsible for policy and the regulator. Currently, the ministry responsible for policy currently has limited capacity.

Action points for implementing the initiation phase
Clarify responsibilities for implementing, evaluating and adjusting the disposal programme.
Following the initiation phase, the next step is to implement the disposal programme. For some roadmaps, this may involve a process lasting decades or possibly even centuries. It is important to clarify who is responsible for the implementation, evaluation and adjustment of the disposal programme. The Rathenau Instituut sees this as the responsibility of the government, and in particular the ministry responsible for policy.

When establishing the disposal programme, the tasks and responsibilities for implementing that programme should therefore be outlined for each roadmap. In countries such as Belgium, France and the UK, responsibility for implementing the disposal programme lies with the organisation that also advises and assists in the preparation of the disposal programme. As there is no blueprint for this, it is advisable to check at evaluation moments whether implementation of the disposal programme is going smoothly and what could be improved.

Clarify rights and obligations during site selection of specific disposal methods.
It is currently unclear what rights and obligations decentralised authorities have in the site selection process for specific disposal methods. Situations and developments vary across Europe. In countries such as Finland and the UK, local governments have power of veto. In Switzerland, the possibility of a referendum at the cantonal level has been replaced by a federal-level referendum. It is essential for the Dutch government to clarify rights and obligations of decentralised authorities for each roadmap.

This includes determining whether it is desirable to apply the Dutch National Coordination Scheme (*Rijkscoördinatieregeling*: RCR). This scheme is used for spatial decisions that transcend provincial interest, which is likely to be the case for a final repository for radioactive waste (Rathenau Instituut, 2024e). The scheme has been criticised by various parties, as opinions differ on what constitutes a national interest. There have also been claims that central government does not take regional interests sufficiently into account when taking over the role of the region (Andersson Elffers Felix, 2016). This is at odds with the participatory approach recommended by the Rathenau Instituut in this advisory report.

3.2 Organising public participation

Countries in the European Union are obliged to involve their population in decision-making on radioactive waste (Council Directive 2011/70/Euratom). The Dutch government also recognises the importance of this issue (Ministry of Infrastructure and Environment, 2016). Organising public participation can enhance the quality of decision-making and support for this process, for example by introducing new ideas and local knowledge and giving stakeholders a greater voice (Arentsen & Van Est, 2023; NEA, 2003). Past experience shows that a lack of participation can lead to resistance, although public involvement does not guarantee support or progress (Rathenau Instituut, 2023b). The proper organisation is essential to ensure that public participation contributes to an effective and democratic decision-making process.

When organising public participation, choices are made about the purpose, participants and participatory methods. The initiator of participation, usually the government or waste management organisation, determines who is responsible for implementing and evaluating public participation. To this end, the Rathenau Instituut makes the following recommendations:

- set clear goals for public participation;
- ensure appropriate forms of participation;
- strive for representativeness and inclusivity; and

- clarify roles and responsibilities involved in organising participation.

We explain these recommendations below. Figure 9 provides an overview of the recommendations and corresponding action points.

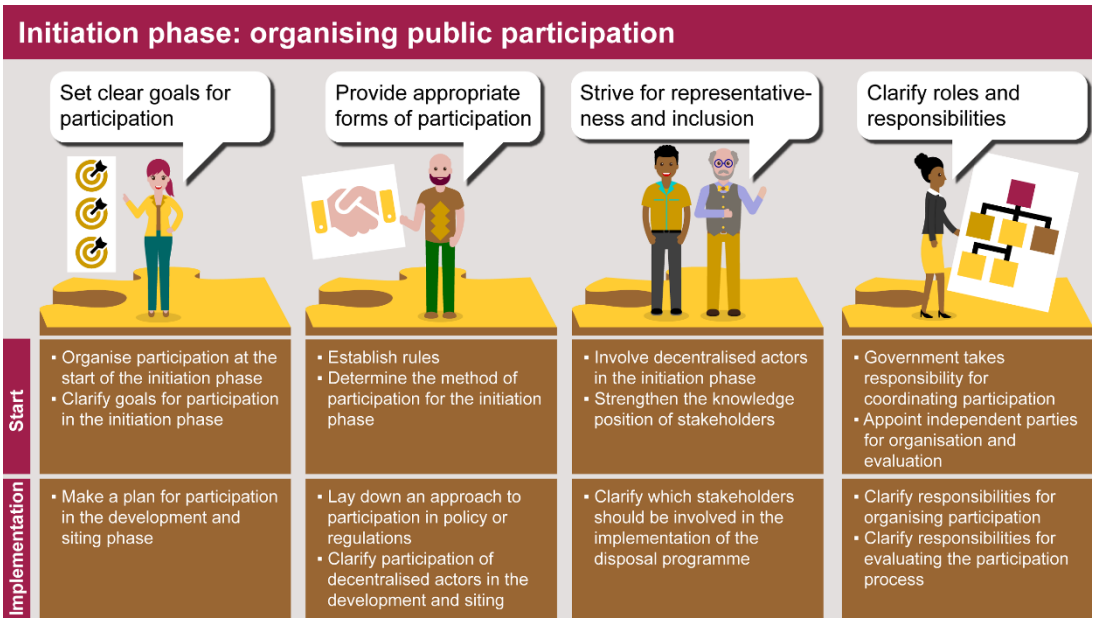

Figure 9 Overview of recommendations and action points for organising public participation during the initiation phase

3.2.1 Clear goals for public participation

Organising public participation can serve several objectives, such as legitimising the decision-making process, increasing support for a chosen location, and improving the design of a management method (Arentsen & Van Est, 2023; TNO, 2023). Establishing a clear goal is essential for organising and evaluating participation effectively. Experts and stakeholders stress that a well-defined goal ensures that participants understand what they can influence and the potential impact of their contribution(Rathenau Instituut, 2023a, 2024a). In terms of encouraging stakeholders participation, it is also important that they can have a say about the goal of participation (Rathenau Instituut, 2015). Misaligned expectations between organisers and participants can lead to resistance (Metze et al., 2023).

Action points for the beginning of the initiation phase
Organise public participation at the start of the initiation phase.
The Rathenau Instituut advises the government to organise public participation, or delegate this task, at the start of the initiation phase. This allows stakeholders and experts to be involved at an early stage in how decision-making, knowledge,

finance and public participation will be organised in this phase. This helps to legitimise the approach and avoid the adoption of an undesirable path in the initiation phase (Ferraro & Martell, 2015; IAEA, 2022).

Clarify the objectives of public participation in the initiation phase.
During the initiation phase, the government should clarify for each step of the decision-making process whether participation will be organised, and if so, for what goal. It may not be desirable or feasible to organise participation at every step. It is important that participation always takes place in relation to key decisions, such as amending policy or legislation, selecting alternative disposal methods and developing the disposal programme roadmaps. Some degree of participation is already required by law, but additional participation is likely to be needed (Rathenau Instituut, 2024c).

Action point for implementing the initiation phase
Clarify in the disposal programme how participation will take place in the development and siting phase.
During the initiation phase, the government should outline through a participatory process how society will be involved within the roadmaps for the various disposal options. Given that this is a socially sensitive issue, the Rathenau Instituut recommends that it should also be made clear in advance how participation will take place in the case of on-site research into a disposal method and site selection. These two activities are inextricably linked and, unlike the initiation phase, take place at the local rather than the national level (Arentsen & Van Est, 2023). Decentralised authorities and local communities should therefore always be involved in this process (Di Nucci et al., 2017).

3.2.2 Appropriate forms of participation

The form of public participation depends on its goal (Bobbio, 2019). The goal may be democratic participation of stakeholders, gain legitimacy for decisions, or obtain knowledge on complex issues. For public participation to be effective, it must be properly implemented and the various processes properly coordinated (Metze et al., 2023). If not, it may do more harm than good (Rathenau Instituut, 2016). For instance, a lack of political and administrative support for a participatory process can lead to politicians not taking its results seriously. This may reduce public trust in the participatory process and wider decision-making (Advisory Committee on Citizen Engagement in Climate Policy, 2021; TNO, 2023). Public participation can then be seen as non-participation or fake participation.

The Rathenau Instituut recommends that participation be shaped with: clear ground rules on aspects such as inclusivity and representativeness, equal access for participants to resources and information, consultation over time, a clearly defined issue, clear political embedding and clarity about the follow-up (Advisory Committee on Citizen Engagement in Climate Policy, 2021; Arentsen & Van Est, 2023; TNO, 2023; WRR, 2023). The desired form of participation is not fixed in advance and may differ per issue. A choice can be made to inform, consult or seek the advice of stakeholders and experts, or to work with them or let them participate in decision-making (see Figure 10). A combination of these forms is also possible.

Figure 10 Different forms of public participation

Action points for the beginning of the initiation phase

Establish rules for organising participation.

To ensure broad public support for public participation, the Rathenau Instituut recommends establishing general rules for this at the beginning of the initiation phase (Rathenau Instituut, 2015). The government may propose some general rules and seek input from stakeholders. Besides this advisory report, the government can also use other recent advices on public participation and citizen consultations as a starting point, as well as the Rathenau Instituut's 2015 vision on public participation (Advisory Committee on Citizen Engagement in Climate Policy, 2021; OECD, 2020; Rathenau Instituut, 2015, 2016; TNO, 2023).

Determine how participation should take place in the initiation phase.

Once the issues for public participation are identified, the government should also clarify, itself or a third party on its behalf, how it will take place. In line with experience from other countries, the Rathenau Instituut recommends focusing on a combination of informing, consulting and advising (see Ferraro & Martell, 2015).

In focus groups organised by the Rathenau Instituut in late 2023 with groups comprising young people and people from Zeeland, participants were more likely to

opt for informing and consulting at the beginning of the decision-making process (Rathenau Instituut, 2024b). However, their views on and expectations of citizen participation vary widely. Some feel that the general public can make a valuable contribution, while others feel citizens lack the knowledge to do so.

Citizens can be consulted through less non-obligatory forms such as citizen panels or focus groups, where they can receive information and participate in discussions with experts and stakeholders. This approach can be useful because the topic is complex and often far removed from the people (Rathenau Instituut, 2024b, 2024a). In addition, the government can learn about the views, ideas and suggestions of special target groups through training programmes and focus groups.

Action points for implementing the initiation phase

Anchor the public participation approach in policy or regulations.
The Rathenau Instituut advises the government to incorporate the public participation approach being developed as part of the disposal programme into policy, and preferably into legislation as well (Rathenau Instituut, 2024e). This can be achieved by drafting a separate regulation or expanding an existing one. Such regulations could then establish rules and principles with regard to who should be engaged and when, how this engagement will take shape, and how the results of the participation process will be incorporated into decision-making. This would ensure greater clarity, transparency, and political and administrative support.

Clarify the desired level of participation of local communities and decentralised authorities during the development and siting phase.
The Rathenau Instituut recommends clarifying the desired level of participation of local communities and decentralised authorities in the development and siting phase. Participants in the aforementioned focus groups (comprising of young people and residents of Zeeland) often felt that the general public should have more influence on site selection, whereas they consider the choice of a disposal method more an issue for experts (Rathenau Instituut, 2024b).

Other countries sometimes choose to give decentralised authorities and local communities more influence on site selection, for example by relying on voluntary registration and participation of municipalities, setting up cooperation in the form of partnerships or granting them veto power (Arentsen & Van Est, 2023; Di Nucci et al., 2017). For example, in Belgium, a partnership model was used for a near surface disposal, involving representatives from the municipal council, residents, the ministry and waste management organisations. They together deliberated on the site selection, compensation measures and implementation of a near surface disposal facility (Bergmans et al., 2023; de Bock, 2023). The regulator FANC oversaw the process to ensure that the solutions developed met safety

requirements (Lidskog & Andersson, 2002). Although the process faced challenges, it ultimately fostered trust and enabled the implementation of a solution.

3.2.3 Representativeness and inclusiveness

The Dutch rules on participation differentiate between *the public* and *the concerned public* when determining who has the right to participate (Rathenau Instituut, 2024e). For example, national-level plans and programmes involve the general public, such as citizens, associations and organisations. Specific projects and licences engage the concerned public, which has a direct interest. If the rules do not prescribe who may participate, the initiator of the participation can in principle determine this.

For the quality and legitimacy of public participation, it is important that all perspectives are as well represented as possible and that no groups are excluded (Advisory Committee on Citizen Engagement in Climate Policy, 2021; TNO, 2023). The Rathenau Instituut therefore advises the government to always strive for inclusiveness and representativeness, even if this ideal is not achievable in practice. Barriers such as low literacy, limited digital skills, health, location and time can make it difficult for people to take part. It is therefore essential to make participation accessible.

Action points for the beginning of the initiation phase
Allow decentralised actors to participate in the initiation phase.
Some international organisations recommend involving regional and local actors mainly during the development and siting phase (IAEA, 2022). However, the Rathenau Instituut recommends that the government should involve representatives of provincial, regional and local actors as early as the initiation phase. The reason for this approach is that decisions taken in that phase, such as on the procedures for choosing a location, can have significant impact on them in later phases. At present, such regional participation only applies to parties from Zeeland who are or have been involved in the storage facility at COVRA. It is important that other provincial, regional and local actors also have the opportunity to represent their interests (Ferraro & Martell, 2015; Rathenau Instituut, 2024b).

Strengthen the knowledge position of stakeholders.
Effective participation requires access to relevant knowledge and expertise. The Rathenau Instituut therefore advises the government to strengthen the knowledge position of stakeholders (see 3.3 Organising knowledge).

Action points for implementing the initiation phase
Clarify which stakeholders should be involved in the implementation of the disposal programme.
The disposal programme should outline how participation will be organised at key steps. The Rathenau Instituut recommends that the government clarify the stakeholders for each roadmap for each key step. This will prevent target groups from being overlooked.

3.2.4 Clear roles and responsibilities for organising participation

In the Netherlands, the government and regulator are legally required to submit draft decisions to society for the purpose of public consultation (Rathenau Instituut, 2024d). COVRA, for example, needs to involve the local population when applying for licences to build a waste management facility, as it did for the current above-ground storage (Rathenau Instituut, 2023b, 2024e). When participation follows existing legal procedures, roles and responsibilities are generally well-defined. The law may also leave room in this area or parties may choose to organise participation when it is not mandatory, for example to allow for participation earlier in the decision-making process. The latter is known as extra-statutory participation. In such cases, roles and responsibilities are less clear.

Experiences in other countries show that different organisations can be involved in coordinating and implementing public participation (Arentsen & Van Est, 2023). France has a law requiring the *Commission nationale du débat public* (CNDP) to involve society in decisions on infrastructure projects, including radioactive waste management. The CNDP organised a public debate after completing a 15-year research programme on disposal options (Lehtonen, 2023). In Belgium, waste management organisation ONDRAF/NIRAS coordinates public participation, but outsources its implementation to external parties like the King Baudouin Foundation (King Baudouin Foundation, 2024a). In the UK, a committee was created to organise decision-making and public participation: the Committee on Radioactive Waste Management (CoWRM).

The Rathenau Instituut advises the government to clarify who has what roles and responsibilities in organising participation. When possible, it is wise to use external organisers, provided they meet the following conditions: political and administrative independence, independence from waste producers, openness, transparency and experience of organising participation (Rathenau Instituut, 2015, 2024a). Furthermore, participation processes should be evaluated by an independent entity, unaffiliated with the initiator (TNO, 2023). Independent evaluations are essential for

ensuring process quality, enabling collaborative learning, and strengthening trust and credibility in the process (OECD, 2020).

Action points for the beginning of the initiation phase

The government should take responsibility for coordinating public participation in the initiation phase.

The Rathenau Instituut sees the government as the main initiator of participation in this phase, as it is responsible for the decision-making process (Rathenau Instituut, 2024a). The government needs to ensure that the various participatory activities are well coordinated, sustain each other and do not obstruct each other (Metze et al., 2023; Rathenau Instituut, 2016). It also needs to ensure sufficient resources for organising participation, possibly according to the polluter pays principle (Advisory Committee on Citizen Engagement in Climate Policy, 2021).

Employ an external party to organise and evaluate participation.

The Rathenau Instituut advises the government to outsource the organisation and evaluation of participation at the beginning of the initiation phase (Rathenau Instituut, 2015; TNO, 2023). Preferably to parties with knowledge and experience, who are politically independent and not tied to companies and organisations that produce radioactive waste (Rathenau Instituut, 2016). One exception to this is participatory activities that are required by law, because the government is responsible for implementing them (Rathenau Instituut, 2024e). Such activities include amending policies and legislation, for which procedures already exist.

Action points for implementing the initiation phase

Clarify roles and responsibilities for public participation in the following phases.

During the initiation phase, the government should outline how participation will take place in the evaluation of the disposal programme and its implementation. It needs to be clear who the initiator is, such as the government or the waste management organisation, and how this process will be funded.

Clarify duties and responsibilities for evaluating the public participation process.

Monitoring and evaluating participation processes is crucial for ensuring its effectiveness (OECD, 2020; TNO, 2023). The organisation conducting the evaluation must be independent, neutral and have sufficient time and budget available. If these requirements are not met, it is better not to proceed with the participation process (Advisory Committee on Citizen Engagement in Climate Policy, 2021; TNO, 2023). TNO (the Netherlands Organisation for Applied Scientific Research) has developed an evaluation framework that can be used for public participation processes. This framework looks at process design, process flow, impact on policy, and influence on wider society (TNO, 2023).

3.3 Organising knowledge

The government has a statutory duty to ensure that knowledge is available for radioactive waste management (2011/70/Euratom, Article 8). The organisation of knowledge is essential for making informed decisions and developing disposal methods. This involves technical knowledge, but also knowledge on issues such as social and legal aspects. The aim of organising knowledge is to ensure that the right knowledge is available to the right people and organisations at the right time. Furthermore, it is crucial that there is trust in how the knowledge has been produced, for example that it has been generated independently.

The government can organise knowledge by making agreements per phase about the identification of knowledge needs, the development and collection of knowledge, availability and preservation of knowledge, and about the clear assignment of roles and responsibilities (Rathenau Instituut, 2023a). The Rathenau Instituut makes the following recommendations:

- develop a knowledge agenda through a participatory process;
- ensure diversity in knowledge and knowledge providers;
- make knowledge accessible and available to a broad public; and
- clarify roles and responsibilities for organising knowledge.

We explain these recommendations below. Figure 11 provides an overview of the recommendations and corresponding action points.

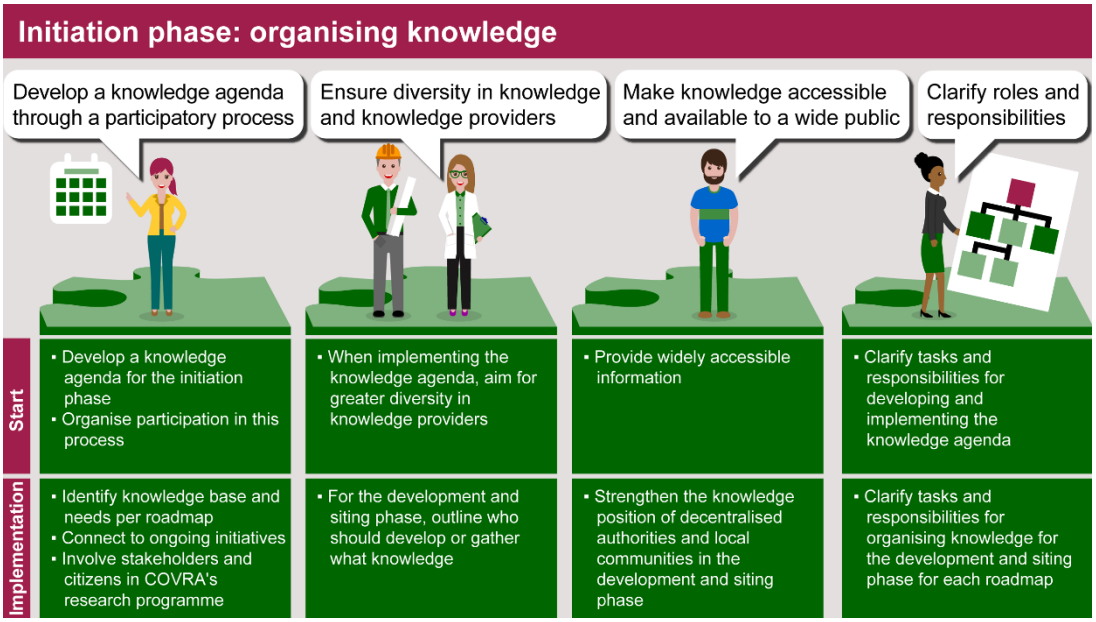

Figure 11 Overview of recommendations and action points for organising knowledge during the initiation phase

3.3.1 Participatory development of a knowledge agenda

Once the government has determined what steps it wants to take in a decision-making phase, it can identify what knowledge is needed to support these steps. The Rathenau Instituut recommends combining these knowledge needs in an overarching knowledge agenda. This agenda would clarify knowledge questions, gaps, uncertainties, and the specific knowledge needed at different stages. The agenda, made up of several action lines, can safeguard the integration of knowledge types (such as technical, governance, social science and practical knowledge) and ensure that knowledge is available in time for decision-making and provides the information that is needed at that time.

The government should periodically update the knowledge agenda. Including the agenda in the *National Programme* could help to guide knowledge development more than is currently the case. Both stakeholders and experts need such guidance (Rathenau Instituut, 2024c). Stakeholders and experts also need knowledge to fulfil their role in the decision-making process at different stages (Arentsen & Van Est, 2023; Rathenau Instituut, 2024c). Partly for this reason, the Rathenau Instituut recommends that universities, decentralised authorities, civil society organisations and citizens also participate in the drafting of the knowledge agenda. This would enable transdisciplinary development of the agenda.

Action points for the beginning of the initiation phase
Develop a knowledge agenda for the initiation phase.
Currently, no overarching knowledge agenda exists for decision-making on the long-term management of radioactive waste (ARTEMIS, 2024; Rathenau Instituut, 2024d). The Rathenau Instituut advises the government to start developing a knowledge agenda in line with the steps to be taken in the initiation phase, such as updating policy and drafting a disposal programme.

Organise participation in drawing up the knowledge agenda for the initiation phase.
The knowledge agenda should be developed through a participatory process. This means that ministries, the ANVS, COVRA, universities, public knowledge institutions, decentralised authorities, civil society organisations and citizens can also take part in identifying knowledge needs. The latter three parties currently have little or no involvement in knowledge development on radioactive waste management, despite a clear need for their involvement (Rathenau Instituut, 2024b, 2024d).

Since different actors have different ideas about what is important, and different positions of power, organising such a process is complex (Rathenau Instituut, 2024c). It is therefore important to learn from similar initiatives, such as the Dutch Climate Research Initiative (*Klimaatonderzoek Initiatief Nederland*, KIN). The KIN is a governing body set up under the Dutch Research Council (*Nederlandse Organisatie voor Wetenschappelijk Onderzoek*, NWO) with the support of knowledge institutions. KIN's aim is to ensure that climate research contributes more effectively to the climate challenge. According to the KIN, this requires a 'different kind of science', including through more intensive collaboration with parties outside the scientific field (KIN | NWO, 2024).

Action points for implementing the initiation phase

Identify knowledge needs and the existing knowledge base for each roadmap.
A roadmap outlines how a disposal option will be further explored and researched and potentially developed and implemented. In the initiation phase, the government needs to identify the existing knowledge base and future knowledge needs for each roadmap. For geological disposal, COPERA, COVRA's research programme, can be used to this end. Where the development of specific roadmaps also involves site-specific research, the Rathenau Instituut recommends paying particular attention to the knowledge needs of decentralised authorities and local communities (Arentsen & Van Est, 2023).

Align the knowledge agenda with ongoing national and international initiatives.
The government must ensure proper alignment and integration of ongoing research activities with the overarching knowledge agenda (Rathenau Instituut, 2024b). For geological disposal, a lot of knowledge is already being developed under the leadership of COVRA. Radioactive waste is also one of the themes to be addressed in the coming years under the Multi-Year Mission-Driven Innovation Programme (MMIP) for Nuclear Energy. This MMIP for Nuclear Energy has a budget of €65 million from the Climate Fund. A key international initiative is EURAD, a joint research programme of organisations from 23 EU Member States.

Engage stakeholders, including citizens, in COVRA's research programme.
COVRA currently coordinates research on final disposal within the multi-year research programme COPERA. To this end, COVRA is developing 'generic safety cases' to devise final disposal concepts and demonstrate their safety (COVRA, 2020). Generic means that the research has not yet focused on a specific site. According to the NEA, input from stakeholders, including citizens, can strengthen the safety case methodology (NEA, 2008). The Rathenau Instituut therefore advises the government to ensure this input, as it is currently lacking. Safety cases

play an important role in the various phases of a roadmap for geological disposal (IAEA, 2023a).

3.3.2 Diversity in knowledge and knowledge providers

Once the knowledge agenda has been established, the government, or a party assigned by the government, must decide who will implement it. The Rathenau Instituut recommends ensuring diversity in knowledge and knowledge providers. Because radioactive waste management is a technical and societal issue, it is important that other types of knowledge are developed in addition to technical knowledge, such as social science knowledge and practical knowledge from the field (Rathenau Instituut, 2024a, 2024c). Stakeholders and experts argue that if knowledge is too one-sided, this can lead to a lack of confidence in that knowledge. A greater diversity of knowledge providers also contributes to the spread of knowledge (and thus power) and the emergence of counter-expertise, which is necessary to critically question and replicate knowledge (Rathenau Instituut, 2024a). Experiences in other countries show that this is important for decision-making on radioactive waste management, as it enhances trust in the knowledge being used (Arentsen & Van Est, 2023).

Action point for the beginning of the initiation phase
Aim for greater diversity in knowledge providers when implementing the knowledge agenda during the initiation phase.
Many experts and stakeholders consider the knowledge and experience in the Netherlands in the field of radioactive waste management too concentrated among a small group of experts. This group includes COVRA, NRG and Delft University of Technology (Rathenau Instituut, 2024c). The loss of a single organisation or even a few individuals may therefore be difficult to absorb (Rathenau Instituut, 2024c; Technopolis, 2016). In addition, social science knowledge is lacking at the national level, although it may be present at international level. By promoting a greater diversity of knowledge and wider range of knowledge providers, the government can, like countries such as Belgium, Germany, France and Switzerland, broaden the knowledge field and make it more vital and thus future-proof (Bergmans et al., 2015; Di Nucci & Brunnengräber, 2023; Kuppler et al., 2023; Lehtonen, 2023). The participatory development of the knowledge agenda plays an important role in this process, as it also raises non-technical knowledge questions (Arentsen & Van Est, 2023).

Action point for implementing the initiation phase
Determine in broad terms who should develop or gather knowledge for the development and siting phase.

With a view to the next phase (the development and siting phase), the Rathenau Instituut recommends outlining in advance who should be responsible for developing or gathering what knowledge, with a focus on interdisciplinary and transdisciplinary research and international cooperation. This involves developing various types of knowledge, for purposes such as exploring and elaborating different management options and organising public participation, finance and decision-making (Rathenau Instituut, 2024b). It is also important that the knowledge needs of decentralised authorities and local communities are taken into account so that they can actively take part in decision-making (Di Nucci et al., 2017).

3.3.3 Widely accessible and available knowledge

For knowledge to effectively contribute to the decision-making process, it must be both usable and utilised. Availability and accessibility are key factors in this regard. The Rathenau Instituut recommends that the government provide easily understandable and up-to-date information. It must also provide stakeholders such as civil society organisations, regional authorities and local communities with resources to close any knowledge gaps compared to parties such as public authorities or the waste manager (Rathenau Instituut, 2015; Swahn, 2023). Experiences in other countries show that civil society organisations, local communities and decentralised authorities can thus increase their control over the decision-making process, and gain more confidence in its outcomes (Arentsen & Van Est, 2023; Di Nucci et al., 2017). The result will be a more even playing field when it comes to knowledge, allowing these parties to play their role more effectively in decision-making.

Action point for the beginning of the initiation phase
Provide widely accessible information.
Decentralised authorities, civil society organisations and citizens have expressed that their knowledge about radioactive waste management is limited (Rathenau Instituut, 2015, 2023a, 2024a, 2024b). Decentralised authorities require a clearer understanding of their role in decision-making so that they can better assess what knowledge they need at what time. Citizens need better information, for example on what radioactive waste is, how it is managed and what the plans are for its future management. To ensure the involvement of these groups in decision-making, the government needs to invest in widely accessible information (Rathenau Instituut, 2015).

Implementing the disposal programme could take many decades to centuries. The government therefore needs to clarify how it will ensure that knowledge remains available and widely accessible over such a long period. For example, Belgian

research highlighted the need for a pluralistic documentation centre that gathers and stores information from various sources so that this knowledge is available to citizens, civil society organisations, politicians and experts (Bergmans et al., 2023). The reason for this is that information should not be one-sided, should show different points of view and should be clear about where uncertainties lie (OECD, 2020; Rathenau Instituut, 2016).

In addition to text-based resources, information can also be provided through other sources, such as direct access to experts and lay experts (Advisory Committee on Citizen Engagement in Climate Policy, 2021). In Belgium, for example, waste management company ONDRAF/NIRAS worked with partners from the municipalities of Dessel and Mol to set up the Tabloo visitor centre. This centre presents information about radioactivity and radioactive waste through videos and objects. The visitor centre, which is located near a repository for low-level and intermediate-level radioactive waste, was a societal condition of both municipalities and is intended to keep the information available for the next 300 years (Tabloo, z.d.).

Action point for implementing the initiation phase
Clarify how the knowledge position of decentralised authorities and local communities will be strengthened in the development and siting phase.
For the development and siting phase, it is important that the decentralised authorities and local communities have a strong knowledge position (Arentsen & Van Est, 2023). This will enable them to be more equal consultation partners for central government and COVRA and to protect their own interests. Countries strengthen these knowledge positions in different ways. In Belgium, France and the UK, for example, local communities receive funding for research on knowledge questions. In Switzerland, there is a dedicated technical safety forum that discusses and answers citizens' questions on safety. This forum is chaired by the nuclear regulator ENSI. Members come from the federal government, decentralised authorities, municipalities from neighbouring countries, NGOs and the public concerned. Regional actors in Switzerland are also given resources to invite experts of their choice to read and comment on technical reports (Kuppler et al., 2023).

3.3.4 Clear roles and responsibilities for organising knowledge

The Rathenau Instituut advises the government clearly define roles and responsibilities for organising knowledge. This includes identifying who is responsible for coordinating, developing, funding and implementing the knowledge agenda, gathering and making information accessible, and driving and integrating

international cooperation (Rathenau Instituut, 2024c). Effective coordination ensures that knowledge contributes meaningfully to decision-making. A common goal is important, as is ensuring connections between disciplines, areas of expertise and domains. These roles and responsibilities will shift depending on the decision-making phase. Periodic evaluation is therefore essential.

Action point for the beginning of the initiation phase
Clarify tasks and responsibilities for developing and implementing the knowledge agenda.
Currently, stakeholders and experts are unclear about who is responsible for organising the knowledge for decision-making on radioactive waste management. COVRA coordinates technical research into final disposal based on its role as a waste management organisation. Several parties express their appreciation for COVRA's efforts in this area (Rathenau Instituut, 2024c). Others find the current situation in which COVRA largely formulates and coordinates the knowledge questions undesirable. They feel that control by the Ministry of Infrastructure and Water Management is lacking, and believe the Ministry should be allowed to take more control. At the same time, some consider it important that responsibility for coordinating knowledge does not lie solely in the hands of the government or COVRA, but should be shared among multiple parties.

The Rathenau Instituut advises the government to clearly define, at the start of the initiation phase, the tasks and responsibilities of various parties in developing, managing and implementing the knowledge agenda. The Netherlands can draw on examples in this area from abroad (Arentsen & Van Est, 2023). In other countries, tasks relating to the organisation of knowledge are often performed by different organisations.

Sweden, for example, set up a special national council for radioactive waste (KASAM) to organise knowledge. This was an advisory body to the Swedish government. Besides advisory reports, KASAM also carried out independent assessments of radioactive waste management and research. These assessments took into account not only technical, but also ethical and social aspects (Kaiserfeld & Kaijser, 2021). The council was dissolved in 2023, following the granting of a licence for the construction and operation of a Swedish interim storage and geological repository in 2022.

France has introduced a statutory requirement for the responsible ministry to draw up a radioactive waste management plan every three years in collaboration with the regulator. This plan also provides guidance for research on specific waste types and disposal options. It is discussed in parliament and with the public (Autorité de sûreté nucléaire & Ministère de la Transition écologique et solidaire, 2018;

Lehtonen, 2023). The public waste management organisation Andra conducts part of this research (Lehtonen, 2023).

Switzerland is another country that involves multiple actors in the knowledge agenda. Waste management organisation Nagra prepares a research programme every five years that is reviewed by the federal energy office (SFOE) and the nuclear regulator (ENSI). This enables them to tailor their own research accordingly and communicate their knowledge requests to Nagra in a timely manner. Nagra also runs its own programme. In addition, several universities and related institutions carry out basic and social science research into radioactive waste management (Kuppler et al., 2023). Regional actors have resources to hire expertise to answer their own knowledge questions.

In Germany, BASE, a type of federal regulator, plays a central role in setting the social and technical research agenda and conducting the research (Di Nucci & Brunnengräber, 2023).

Action point for implementing the initiation phase
Clarify tasks and responsibilities for organising knowledge for the development and siting phase for each roadmap.
In the initiation phase, the government needs to clarify for each roadmap who has what tasks and responsibilities for organising knowledge. An important consideration here is the role of COVRA, which is responsible for radioactive waste management and the associated research (Rathenau Instituut, 2024d). That research is paid for from waste fees and focuses mainly on geological disposal. The government needs to clarify the implications of exploring alternative disposal methods for COVRA's research activities, the role of the safety case and for funding this research. After all, investigating alternatives means broadening the scope of current research and therefore higher costs.

3.4 Organising finances

The Netherlands is obliged by law to have sufficient financial resources for long-term radioactive waste management (2011/70/Euratom). This is needed for management and disposal, but also for activities such as research, decision-making and public participation. Finances need to be organised so that there are sufficient resources for these activities, both now and in the future. The effective organisation of financial monitoring is also important. It needs to be clear who pays what and whether costs are set in a sufficiently transparent, objective and non-discriminatory manner.

Finances need to be organised so that sufficient funds are available at the right time. For this, it is important to clearly state when what costs can be expected, how these costs will be paid and who has what responsibilities.
he Rathenau Instituut makes three recommendations with regard to organising finance:

- make a transparent cost estimate
- determine how and by whom costs will be paid, and
- clarify roles and responsibilities for managing finances.

We explain these recommendations below. Figure 12 provides an overview of the recommendations and associated action points.

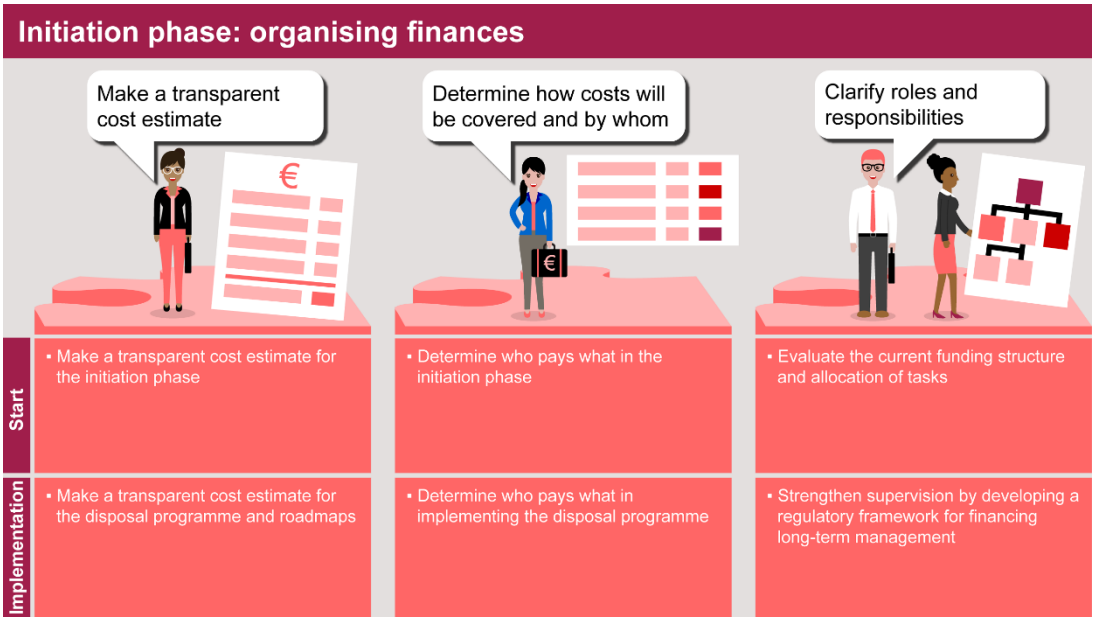

Figure 12 Overview of recommendations and action points for organising finances during the initiation phase

3.4.1 Transparent cost estimates

At this time, there is no cost estimate for the entire process that should lead to the Netherlands eventually having a final repository. The IAEA has recommended that such a cost estimate is made (IAEA, 2020). In its cost estimate, COVRA only focuses on the costs of above-ground storage and final disposal (Verhoef et al., 2017). This cost estimate offers limited transparency to the public and is difficult for outsiders to understand. Experts and stakeholders require more insight into how COVRA calculates costs and assesses financial risks (Rathenau Instituut, 2023a). The Rathenau Instituut therefore recommends that the government provide

transparent cost estimates for the entire process, including research, participation, choice of location and alternative disposal options.

Action point for the beginning of the initiation phase
Make a transparent cost estimate for the initiation phase.
The Rathenau Instituut recommends clarifying at the start of the initiation phase what costs are needed to organise decision-making, participation and knowledge during that phase. This estimate should be public and accessible. There are two reasons for making this cost estimate transparent. Firstly, it will clarify what activities will be carried out within the three processes – organising decision-making, public participation and knowledge – and how much they will cost. Secondly, it allows an assessment of what is feasible and desirable based on this cost estimate.

Action point for implementing the initiation phase
Make a transparent cost estimate for the disposal programme and roadmaps.
When developing the disposal programme, the government should provide an initial cost estimate for each roadmap. It will not yet be possible to make an accurate estimate for the entire process for each waste management option during this phase. The Rathenau Instituut therefore recommends a conservative estimate based on costs that are higher than the likely costs, thus reducing the risk of disproportionately burdening future generations with disposal costs. In addition, the government must take into account uncertainties that may affect the resources needed. For example, changes in radioactive waste policy and nuclear ambitions may lead to a change in the expected amount of waste and its distribution between the different categories. Choosing one or more disposal methods and the timing of their implementation may also impact the resources required (Nuclear Energy Agency, 2021).

3.4.2 Who pays what costs?

The Netherlands adheres to the polluter-pays principle for financing radioactive waste management. COVRA is mandated to determine waste management costs in a transparent, objective and non-discriminatory manner (Article 10.10, Bbs (*Besluit basisveiligheidsnormen stralingsbescherming*, Kingdom Relations, no date). This includes costs incurred by COVRA for research and development in relation to radioactive waste management, but it is not clear at the moment what exactly this covers. It is also not clear who should pay the costs of organising decision-making, public participation and knowledge (Rathenau Instituut, 2024a). Should the waste producers pay these costs, or is this the government's responsibility? The Rathenau Instituut therefore recommends making clear agreements on who pays what costs

for radioactive waste management, including decision-making costs, participation costs and the costs of technical and other knowledge.

Action point for the beginning of the initiation phase
Determine who pays for what in the initiation phase.
The Rathenau Instituut advises the government to clarify, based on the transparent cost estimate from the initiation phase, who will bear these costs, and how the polluter-pays principle will be implemented in this context. In other European countries, for example, waste producers share in the costs of participation processes. This is the case in Germany and the UK (Di Nucci & Brunnengräber, 2023; Simmons & Bickerstaff, 2006).

Action point for implementing the initiation phase
Determine who pays what in the disposal programme.
The disposal programme consists of several roadmaps that also require the government to determine who pays for what, for instance in the event of the decision to compensate municipalities if they accommodate a facility. In other countries, it is common for waste producers to contribute towards these costs (IAEA, 2020). Another issue is the cost of researching different management options. At present, these costs are largely covered by waste fees. The COPERA research programme has 3 FTE researchers employed by COVRA, plus an annual research budget of €700,000, which is supplemented through international research programmes and partnerships. Experts and stakeholders consider these resources insufficient (Rathenau Instituut, 2024c).

3.4.3 Clear roles and responsibilities for organising finances

Defining roles and responsibilities for organising finance is crucial. This means, among other things, distributing potentially conflicting interests among different organisations and ensuring proper public oversight of financial management, such as charging and collecting fees, managing and investing capital, and monitoring financial resources. The Rathenau Instituut recommends considering for each phase whether the existing allocation of tasks and responsibilities is still adequate. This involves look at the planned activities, who should carry them out and whether the existing financial arrangements are still adequate.

Action point for the beginning of the initiation phase
Evaluate the current funding structure and allocation of tasks.
Once it is clear who pays for what, the government needs to clarify whether the current structure and allocation of tasks, in which COVRA collects and manages the waste fees, is still desirable. For example, some stakeholders and experts believe

that the government, as the party with ultimate responsibility, should play a greater role in this context (Rathenau Instituut, 2024a). Many other European countries, such as Germany, Belgium, Switzerland, Sweden and Finland, opt for a public fund.

In Switzerland, a radioactive waste fund was set up in 2000 and is managed together with a previously established decommissioning fund for nuclear facilities (STENFO) (Kuppler et al., 2023). The two funds are legally separate. After Germany passed a law in 2013 for a step-by-step approach to choosing a location for a final repository, and set up the institutional framework for this, it established a radioactive waste management fund (KENFO) in 2017. As part of a review of its nuclear policy, Belgium set up the Hedera state fund. Commercial and public waste producers deposit capital into the fund, which needs to increase to at least €60 billion. Hedera is supervised by the Parliamentary Committee for Nuclear Facilities (Steel, 2023).

Such funds facilitate the deployment of resources to organise various activities. Several experts and stakeholders argue that a public fund could also ensure a high degree of continuity and a direct link between policy and financial management in the Netherlands (Rathenau Instituut, 2024a).

Action point for implementing the initiation phase
Strengthen supervision by developing a regulatory framework for financing long-term management.
It is important that the government strengthens its supervision to ensure the effective organisation of financing. There is currently no regulatory framework for the financing of long-term management and therefore for the disposal programme. Both the ANVS Advisory Board and the experts and stakeholders consulted have raised this gap (ANVS Advisory Board, 2020; Rathenau Instituut, 2023a, 2024a). Such a framework makes it possible to assess the justification for the budget and facilitates the monitoring of capital growth. This would be in line with international recommendations (Nuclear Energy Agency, 2021).

France, which adopted the Nuclear Transparency and Safety Act in 2006, is an interesting example. The Act introduced a National Assessment and Funding Committee (CNEF), which evaluates the long-term costs of radioactive waste. This Act also provided for supervision by the Ministry of Finance of the financing of waste management organisation Andra. A few years earlier, the French Court of Audit *(Cour des Comptes*) had already been given a greater role in supervising the finances of the French disposal project Cigéo (Lehtonen, 2023).

3.5 Overview of action points

This chapter discussed the processes for organising decision-making, public participation, knowledge and finance are discussed as separate activities. In practice, they are sometimes difficult to separate. In fact, in order to achieve synergy, knowledge development, public participation and decision-making must often go hand in hand. Since these activities cost money, financing cannot be overlooked. The Rathenau Instituut believes that the government plays the most important role in organising these processes in a democratic and effective way, to achieve solutions that enjoy broad public support.

Appendix 1 lists all the action points from this chapter for the beginning of the initiation phase. Appendix 2 contains the action points for implementing the initiation phase. These points are intended as an agenda for the coming decades.

4 Closing words

This advisory report outlines a step-by-step approach for the government to engage with society in addressing the long-term management of radioactive waste. By taking steps together now, the government can involve society while options are still open, better respond to opportunities and uncertainties, and avoid passing unreasonable burdens on to future generations. This will also create the clarity needed on the management of radioactive waste, given the government's nuclear energy plans.

The Rathenau Instituut recommends that the government include in the 2025 *National Programme* a commitment to initiate a participatory, step-by-step approach aimed at finding a solution in five phases. In addition to geological disposal, the government should already include other potential disposal options in the *National Programme*, to be explored within a disposal programme. The feasibility and desirability of these options should be discussed in proper consultation with society, leading to the adoption of a disposal programme. And finally, the government should clearly state in the *National Programme* that it will collaborate with society in each phase to determine the knowledge, policy, public participation and financing needed to reach widely supported decisions.

Appendix 1: recommendations and action points for the beginning of the initiation phase

Recommendations	Action points for the beginning of the initiation phase
For organising decision-making	
Clearly articulate what the decision-making is about	*Outline the specific steps involved in the initiation phase.*
Develop clear procedures	*Formulate principles for decision-making on the long-term management of radioactive waste.* *Identify which steps require new procedures.*
Clarify and allocate roles and responsibilities for organising decision-making	*Clarify who is responsible for the steps to be taken in the initiation phase. Ensure that the ministry responsible for policy has sufficient capacity and expertise.*
For organising participation	
Set clear goals for public participation	*Organise public participation at the start of the initiation phase so that stakeholders and experts can contribute at an early stage.* *Clarify the objectives of public participation in the initiation phase.*
Ensure appropriate forms of participation	*Establish general rules for organising participation.* *Determine how participation should take place in the initiation phase.*
Strive for representativeness and inclusion	*Allow decentralised actors to participate in the initiation phase.* *Strengthen the knowledge position of stakeholders.*
Clarify roles and responsibilities involved in organising participation.	*The government should take responsibility for coordinating public participation in the initiation phase.* *Employ an external party to organise and evaluate participation.*
For organising knowledge	

Develop a knowledge agenda through a participatory process.	*Develop a knowledge agenda for the initiation phase.* *Organise participation in drawing up the knowledge agenda for the initiation phase.*
Ensure diversity in knowledge and knowledge providers.	*Aim for greater diversity in knowledge providers during the implementation of the knowledge agenda during the initiation phase.*
Make knowledge accessible and available to the public.	*Provide widely accessible information so that stakeholders can play their part in the decision-making process.*
Clarify roles and responsibilities for organising knowledge.	*Clarify tasks and responsibilities for developing and implementing the knowledge agenda.*

For organising finances

Make a transparent cost estimate.	*Make a transparent cost estimate for the initiation phase.*
Determine how and by whom costs will be paid.	*Determine who pays for what in the initiation phase.*
Clarify of roles and responsibilities for managing finances.	*Evaluate the current funding structure and allocation of tasks.*

Appendix 2: recommendations and action points for implementation of the initiation phase

Recommendations	Action points for implementation of the initiation phase
For organising decision-making	
Clearly state what the decision-making is about.	*Clarify what steps the roadmaps consist of.*
Develop clear procedures	*Establish a participatory process for periodic evaluation and adjustment of the disposal programme.* *Adopt a statutory regulation in a timely fashion.*
Clarify and allocate roles and responsibilities for organising decision-making.	*Clarify who will be responsible for implementing, evaluating and adjusting the disposal programme.* *Clarify rights and obligations during site selection of specific disposal methods.*
For organising participation	
Set clear goals for public participation.	*Clarify in the disposal programme how participation will take place in the development and siting phase.*
Ensure appropriate forms of participation.	*Anchor the public participation approach in policy or regulations.* *Clarify the desired level of participation of local communities and decentralised authorities during the development and siting phase.*
Strive for representativeness and inclusion.	*Clarify which stakeholders should be involved in the implementation of the disposal programme.*
Clarify roles and responsibilities involved in organising participation.	*Clarify roles and responsibilities for public participation in the following phases.* *Clarify duties and responsibilities for evaluating the public participation process.*
For organising knowledge	
Develop a knowledge agenda through a participatory process	*Identify knowledge needs and the existing knowledge base for each roadmap.* *Align the knowledge agenda with ongoing national and international initiatives.*

	Engage stakeholders, including citizens, in COVRA's research programme.
Ensure diversity in knowledge and knowledge providers.	*Determine in broad terms who should develop or gather knowledge for the development and siting phase.*
Make knowledge accessible and available to a wide public.	*Clarify how the knowledge position of decentralised authorities and local communities will be strengthened in the development and siting phase.*
Clarify roles and responsibilities for organising knowledge.	*Clarify tasks and responsibilities for organising knowledge for the development and siting phase for each roadmap.*

For organising finances

Make a transparent cost estimate.	*Make a transparent cost estimate for the disposal programme and roadmaps.*
Determine how and by whom costs will be paid.	*Determine who pays what in the disposal programme.*
Clarify of roles and responsibilities for managing finances.	*Strengthen supervision by developing a regulatory framework for financing long-term management*

Appendix 3: Supervisory Committee members

- Hans Dröge (Chair), former National Manager, Unilever Netherlands.
- Ruud van Bennekom, Mayor, municipality of Bunnik.
- Ira von Harras, Director, Zeeland Environmental Federation (*Zeeuwse Milieufederatie*).
- Anne Bergmans, Senior University Lecturer, Sociology and Security Sciences, University of Antwerp.
- Pieter Boot, Senior Fellow, CIEP, and former Section Head, PBL Netherlands Environmental Assessment Agency.
- Franka Hummels, Freelance Journalist.
- John Grin, Professor of Public Policy and Governance, University of Amsterdam.
- Noëlle Aarts, Professor of Socio-Ecological Interactions, Radboud University (from December 2021).
- Maarten van Geet, Research, Development and Demonstration Manager, ONDRAF/NIRAS (from March 2023).
- Hans Codée, former Director, COVRA (until October 2022).
- Sanne Akerboom, Assistant Professor in Regulation and Governance of the Energy Transition, Utrecht University (until September 2020).

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