

SPLITTING THE ATOM, SPLITTING OPINION?

DECISION-MAKING ON NUCLEAR ENERGY BASED ON VALUES

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Note: The Dutch version of the advisory report contains an additional analytical section.





SUMMARY

By 2050, our country's energy system will need to be carbon-neutral. In recent years increasing attention has been given to nuclear energy as a means to achieve this climate goal. What do we need to be able to make a widely supported, well-founded decision on whether or not to use nuclear energy? This question is the subject of this advisory report by the Council for the Environment and Infrastructure (Rli).

Decisions on nuclear energy must be taken quickly and diligently

Given the short amount of time left before 2050, the government will have to decide quickly on how to organise the energy system and whether or not nuclear energy will form part of it. However, speed must not go at the expense of diligence.

In the past, taking diligent, future-proof decisions in the area of nuclear energy has proven difficult. This topic has frequently been the subject of fierce public and political debate. As a result, Dutch nuclear energy policy has been anything but stable. Plans for new nuclear power stations have been repeatedly placed on the political agenda, but have been withdrawn time and again. It is important to ensure that decision-making in the field of nuclear energy becomes less erratic in future. After all, a stable energy policy is crucial if we are to keep our 2050 climate targets within reach.

Importance of seriously examining what citizens think about nuclear energy

In our opinion, it will help if the decision-making relating to new nuclear power stations is structured in such a way that, in addition to technical scientific knowledge, citizens' views also form an integral part of the process. Aspects that are important to citizens must be taken into account seriously.

As our analysis shows, however, the underlying views about nuclear energy are often extremely diverse. Nuclear energy is more divisive than other forms of energy and this division is reflected in the public and political debate. It is proving difficult to have a proper discussion about this topic. At the same time, it is notable that, as also revealed by our analysis, about four out of ten people do not have a strong opinion about nuclear energy. The polarisation that characterises the debate on nuclear energy thus does not seem to prevent a relatively large proportion of the population from having a neutral attitude to the subject.

Decision on nuclear energy requires consideration of entire energy system

In this advisory report we have focused on the role of nuclear energy. Policy choices relating to nuclear energy cannot be made in isolation, however. After all, decisions for or against one option have consequences for the others. A decision to exclude nuclear energy from the energy system, for example, means that the policy challenge increases for other forms of energy generation. To make a decision on nuclear energy, a comprehensive assessment is therefore needed of the energy system as a whole.

Views on five values are decisive in nuclear energy debate

The Dutch are concerned about many aspects of our energy system and the role that nuclear energy plays within it. Five values appear to play a central role here: energy supply certainty, affordability, safety and security, sustainability and justice. Our analysis reveals that there are significant differences in how people view these values:

- Many people are concerned about *energy supply certainty*. Will we be able to manage with an energy system in which our energy will soon be obtained almost exclusively from wind and sunlight, for example?
- The *affordability* of energy is another aspect that concerns people. There is anxiety about high energy prices. Some people think that using nuclear energy will lower energy bills, while others think it will increase them.
- *Safety and security* considerations have the greatest influence on what people think about nuclear energy. However, there are conflicting views on the safety and security of nuclear energy. Some people emphasise the low risk of nuclear accidents, while others focus mainly on the large impact that a nuclear accident could have.
- People are also divided when it comes to the *sustainability* of nuclear energy. Everyone recognises that low CO₂ emissions are important from a climate perspective, but a portion of the population considers nuclear energy to be unacceptable as long as the nuclear waste problem has not been resolved.
- Finally, *justice* is a key issue when it comes to nuclear energy. This relates, in the first instance, to the procedural justice or decision-making process: people think that it is important that everyone is listened to and that their own perspective is also visibly taken into account. Secondly, it



concerns distributive justice: people believe that it is important that the benefits and burdens of nuclear energy are distributed justly. Here we are talking, for example, about the choice of location for new nuclear power stations, or the question of to what extent future generations should be burdened with our nuclear waste.

Government: ensure decision-making is properly prepared and well informed

In this advisory report we make a number of recommendations to the government to ensure that decision-making relating to the energy system – and the role of nuclear energy within it – is properly prepared and well informed.

Strengthen the knowledge base underpinning the energy transition and entrust this task to the yet to be established climate council

The government is currently working on the *National Energy System Plan for 2050*. To prepare this plan, we believe that additional knowledge is required so that the added value of nuclear energy within the energy system can be properly assessed. Answers are needed to at least the following questions:

- What is the cost difference between an energy system with and an energy system without nuclear energy?
- Which energy system contributes most to acceleration of the energy transition (and thus to more rapid bending of the global CO₂ emissions curve)?

- What would the direct and indirect consequences be of a possible nuclear accident in the Netherlands, and is the Netherlands sufficiently prepared?
- What technological and financial uncertainties are associated with the final disposal of high-level waste?

It is important that quantitative studies and reports on the above-mentioned questions can be assessed in terms of their underlying assumptions and how they handle uncertainties. We believe that the climate council to be established under the terms of the coalition agreement has a valuable role to play here. This body should fulfil the role of scientific intermediary. We recommend that the climate council should also include experts in the fields of ethics, psychology and sociology, spatial sciences and economics.

Explicitly consider relevant technical aspects and ethical questions

The choices that the government will make in the National Energy System Plan for 2050 require explicit consideration of the following seven policy-related questions:

- How do we intend to deal with peaks and troughs in the supply of wind and solar energy?
- How robustly do we want to organise the energy transition and at what cost?
- What risks of an energy system with or without nuclear energy do we consider acceptable and how will we determine these risks?
- How much importance do we attach to the impact that choosing a particular form of energy generation will have on the landscape?



- How much importance do we attach to the impact of using finite resources when deciding in favour of or against including particular forms of energy generation in the energy system?
- What do we think is a just distribution of the benefits and burdens of the energy system?
- With what consequences of the energy system is it acceptable to burden future generations?

Government: take citizens' views into account in decision-making

In this advisory report, we also make recommendations on how the government can include citizens' views in the decision-making process relating to nuclear energy.

Pay attention to the five values in the debate on the organisation of the energy system

Over the coming years, there will be debate about the organisation of the energy transition at various times – especially when it comes to the possible construction of nuclear power stations. We believe it is important that the government and House of Representatives pay close attention to the five values that are relevant here: energy supply certainty, affordability, safety and security, sustainability and justice in the distribution of benefits and burdens.

Organise civic engagement

The government and House of Representatives will need to involve citizens explicitly in decision-making and clearly inform them about the trade-offs

that they make between these values and the conclusions that they draw from this. Citizens will then more readily accept the outcomes of a decision-making process.

We support the proposal made by the Minister for Climate and Energy Policy, also on behalf of the Minister of the Interior and Kingdom Relations, that the government, together with the House of Representatives, should look into the possibility of establishing a *citizens' assembly* on the development of our future energy system. We believe that in principle a citizens' assembly is an adequate form of citizen participation to advise the government and the House of Representatives about the future energy system and the possible role of nuclear energy therein. The outstanding knowledge questions need to be answered first, however.



1 INTRODUCTION

1.1 Background

The climate targets that the Netherlands has to meet necessitate a rapid energy transition. By 2030, CO₂ emissions must have been reduced by at least 55% and, by 2050, the Netherlands must have a carbon-neutral energy system that largely runs on clean electricity. That means that we have less than 30 years left. In recent years the Netherlands has taken the first steps in this energy transition. It is clear, however, that around the globe, and in the Netherlands too, the achievement of the energy transition is lagging behind the agreements made in the Paris climate agreement in 2015 (IPCC, 2022; PBL, 2021). Policy commitments and implementation will therefore need to be stepped up considerably.

The possibility of taking steps towards achieving the climate targets by building new nuclear power stations has been the subject of increasing attention in our country in recent years, both within the public debate and in the House of Representatives. In the coalition agreement of the fourth Rutte government, the governing parties agreed to make preparations with a view to possibly constructing two new nuclear power stations. The government is keen to generate interest among commercial operators in the possibility of building a nuclear power station and realising the permanent, safe storage of nuclear waste. A sum of €5 billion has been set aside for this purpose. To

make the plan agreed on in the coalition agreement a reality, decisions will have to be made at various moments, triggering a debate on each occasion.

Currently, wind and solar energy form the basis of the transition to a carbon-neutral energy system. However, other forms of generation capacity are needed in addition to wind and solar energy to ensure demand for energy can be met when the wind is not blowing and the sun is not shining. The question is whether and how nuclear energy could play a complementary role within this context. It is important to create clarity on whether we as a society consider the generation of nuclear energy desirable (or at least acceptable), or whether we prefer other options to ensure that we have access to sufficient energy. These other options may involve a combination of energy generation from biomass, natural gas combined with carbon capture and storage, biogas or hydrogen, for example, as well as battery or hydrogen energy storage, but may also include energy imports and demand management. Such choices are expected to provoke a great deal of public debate, both within and outside formal public participation procedures.

Talking about the energy system of the future and the possibility of including nuclear energy in it is no easy task, but it is a necessary one (Boot, 2020). This is a complex subject that involves uncertainties. Technical and financial information is needed to help people get a grasp of the subject in the public debate: what are the risks and costs associated with nuclear energy? Making factual information widely available is not enough, however. There are also underlying beliefs within society that influence the

position people take in the nuclear energy debate. It is important to make these implicit beliefs explicit and acknowledge them in discussions, so that they can be considered transparently when decisions are being made. Taking people's different positions into account in this way is essential. After all, the possibility of integrating nuclear energy into the Dutch energy system depends on policy choices that will have to be made on the basis of society's views. This is important to achieve 'durable', stable policies.

Dutch nuclear energy policy has been anything but stable in recent decades. Plans for new nuclear power stations have been repeatedly placed on the political agenda, but have been withdrawn time and again. It is important to ensure that decision-making in the field of nuclear energy becomes less erratic in future. After all, a stable energy policy is crucial if we are to keep our 2050 climate targets within reach.

1.2 Main question

As mentioned above, the number of years left to realise the energy transition in accordance with the Paris agreements is limited: time is running out. Against that background, the fact that the process of deciding on the possible construction of new nuclear power stations in the Netherlands is relatively time-consuming is a complicating factor – and that is before work on them has even begun. It is therefore important that decisions about the energy system and the possible role of nuclear energy within it are made soon. At the same time, it is essential that decisions (both on the energy transition as a whole and on a potential role for nuclear



power stations) are made diligently. This is the only way to avoid hitches that subsequently hold up the process, caused by certain aspects or views within society having been insufficiently considered. In other words, it is important to achieve ‘future-proof’ decision-making in which all relevant issues have been weighed up. This advisory report therefore focuses on the following question:

What considerations must be made when deciding on a possible role for new nuclear power stations within the carbon-neutral energy system that the Netherlands will have to realise in the near future? And what recommendations can be made based on this for the reflection process and the exchange of views that the government and Parliament must undertake before decisions are made?

1.3 Objective

Our intention with this advisory report is not to make a statement for or against nuclear energy. We also do not pass judgement on the desirability or otherwise of building new nuclear power stations. However, we do aim to identify the issues that we believe should at least be addressed in the debate and decision-making on the role of nuclear energy within the future energy supply.¹ These issues may concern questions that cannot currently be answered due to a lack of sound knowledge, but also, for example,

¹ There may also be other issues that are relevant to the debate.

policy-related dilemmas that involve weighing up values such as safety and security, sustainability, affordability, energy supply certainty and justice.

Our aim with this report is to facilitate the political and public debate on nuclear energy by clarifying what perspectives and issues are relevant and how these can be taken into account when making policy decisions. The underlying idea is that informed policy choices, based on the consideration of *all* relevant substantive and social aspects, contribute to stable policy. We hope that our report will encourage more open discussion of the subject of nuclear energy, which has so far been a divisive issue and has given rise to a polarised debate. In our view, a good discussion about nuclear energy is possible and also important, given the urgency of the climate targets.

1.4 Scope

Our advice is limited to the decision-making on the role that new nuclear power stations could potentially play within the Netherlands’ future energy supply. Extending the life of the existing Borssele nuclear power station is therefore beyond the scope of this advisory report. We also do not comment on the role that possible new nuclear reactors could play in relation to research and medical applications.

Furthermore, in this report we focus exclusively on ‘regular’, so-called generation III(+) nuclear power stations, similar to those currently under construction in France and the United Kingdom, and the one recently commissioned in Finland. This type of technology is available today and



decisions can be made on it now. We expect a new nuclear power station in the Netherlands to be able to supply electricity to the grid from 2035 at the earliest, and thus to contribute to greenhouse gas reduction from that moment on. New nuclear energy generation technologies that may come onto the market in the future, such as small and modular reactors or generation IV nuclear power stations (Jordan and Turkenburg, 2020), are not considered in this report, although they may influence the decision on whether or not to build generation III(+) nuclear power stations.

One final point regarding the scope concerns the target group of this advisory report. Our intention is to set out in an accessible way which issues should at least be discussed and weighed up in the public debate and political decision-making on the possible role of nuclear energy in the Netherlands. This report therefore does not constitute a scientific assessment of the available research on the subject of nuclear energy. It is intended for a wider audience of interested citizens, politicians and policymakers.

1.5 Our approach

This advisory report has been prepared in much the same way as our other advisory reports. The advice is therefore the result of (a) an internal project team's and an internal committee's own analysis, (b) input from specific experts consulted by the Rli, (c) the results of research commissioned by the Rli, (d) larger and smaller meetings with experts and stakeholders and (e) the Council's own reflections on the final result. One peculiarity of this

advisory report is the fact that we involved three external advisers in the process. A more detailed description of the approach taken is presented in Section 1 of Part 2 of the Dutch version of this advisory report.

1.6 Reader's guide

The remainder of this report is structured as follows.

In Section 2 we outline the history of nuclear energy in the Netherlands and the current situation, and we look ahead to the debate we expect to take place on the possible construction of new nuclear power stations in our country. We also highlight a lesson that the government can learn from history when drawing up new plans for nuclear energy.

In Section 3 we introduce the values that the Dutch consider important when it comes to nuclear energy and the organisation of our future energy system. This is the lens through which we look at nuclear energy in the advisory report.

In Section 4 we discuss what the Dutch think about nuclear energy on the basis of the values introduced in Section 3. What do they see as important in relation to each value and what opinions and emotions play a role in shaping their view?

In Section 5 we test the main arguments arising from the public debate on nuclear energy against existing knowledge. Is there any consensus when



it comes to certain facts and values? Are some arguments demonstrably wrong or problematic?

In Section 6 we turn our attention to questions that remain outstanding concerning the possible role of nuclear energy within our future energy system. We take stock of the knowledge that is still lacking and the dilemmas that still require political consideration before a future-proof decision on the future role of nuclear energy can be taken.

Finally, in Section 7, we formulate the conclusions of our analysis and our five recommendations for the government.





2 DEBATE ON NUCLEAR ENERGY PAST AND PRESENT: WHAT DOES IT TEACH US?

Public opinion in our country on the subject of nuclear energy has not remained constant over the years. From the 1950s onwards, the process of uranium fission, which had been discovered shortly before the Second World War, was considered by many to be the energy source of the future. Doubts about the risks associated with nuclear energy first arose among a larger section of the population in the 1970s. Since then, nuclear energy has regularly been the subject of fierce public and political debate. Nuclear accidents such as those in Harrisburg, Chernobyl and Fukushima have contributed to this.

This section first provides a brief outline of the history. We then discuss the current status of the policy plans on the use of nuclear energy. In addition, we look ahead to the decisions that will need to be taken in the foreseeable future to allow potential new nuclear power stations to be built in the Netherlands and that we expect to be the subject of political and public debate. We outline the various viewpoints repeatedly expressed as part of that debate. Finally, we discuss the lesson that the government can learn from history when making new plans in the area of nuclear energy.

2.1 First steps in the field of nuclear energy

In 1957, in the White Paper on Nuclear Energy (*Nota inzake de kernenergie*), the then Minister of Economic Affairs announced the Atomic Energy Act (*Atoomwet*), later renamed the Nuclear Energy Act (*Kernenergiewet*). The first part of this Act came into force in 1963 and marked the start of the construction of a nuclear power station in Dodewaard. This power station was ready for operation in 1969. It had a capacity of 58 megawatts – enough to power a city the size of Arnhem in the 1960s.

The Provinciale Zeeuwsche Electriciteits-Maatschappij (Provincial Zeeland Electricity Company, PZEM) then decided to build a second nuclear power station in Borssele in the province of Zeeland with a net electrical capacity of 485 megawatts. Construction work on this power station started in 1969 and it entered operation in 1973.

At that time most people saw nuclear fission as a safe and infinite source of energy, one that, moreover, did not cause the pollution associated with the use of coal and oil (Koppejan, 2008). In short, nuclear energy was not a controversial issue.

2.2 Broad Public Debate

The Nuclear Energy Act came into full effect in 1970. The purpose of the Act was to stimulate the further development of nuclear energy and, at the same time, to protect people and the environment from the possible dangers (Uylenburg et al., 2006). At that time it was expected that by the year 2000 half of Dutch electricity would be supplied from nuclear power stations (EZ, 1972).

Figure 1: Excerpt from a Stop Kalkar newspaper from 1975



Source: Landelijk Kernenergie Archief (National Nuclear Energy Archive, Laka)

In the years that followed, however, public support for nuclear energy declined. Over the period from 1974 to 1983, for example, there were several protests against the construction of a breeder reactor in Kalkar (just over the German border). The 1979 accident at the Harrisburg nuclear power station in the United States further fanned the flames of opposition within society.

As a result of changing public opinion, the second Van Agt government (1981-1982) took the initiative for what was officially called the Public Debate on Energy Policy, but was referred to as the Broad Public Debate on the role of nuclear energy within the Netherlands' energy supply.

The 2,000 or so public meetings that were held in total revealed that the opinions of supporters and opponents of nuclear energy were some distance apart.² A large majority of the participants were opposed to nuclear energy.

In 1984, in "The Final Report", the steering committee of the Public Debate on Energy Policy advised the government not to build any new nuclear power stations, but to focus on knowledge development and research. In 1985, however, the government decided, partly on the basis of advice from parties including the General Energy Council and the International Energy Agency, to commit to the construction of at least two new nuclear power stations (EZK, VROM, SZW, WVC & BZ, 1985).

² Many years later, in 2005, Jan Terlouw, the minister responsible at the time, said he was rather disappointed at how the Broad Public Debate had turned out: "It became a polarised debate with the same people at the discussion evenings every time."

2.3 Impact of Chernobyl disaster on nuclear energy policy

While the Dutch government was busy deciding on new nuclear power stations, in 1986 a nuclear disaster occurred in the Ukrainian city of Chernobyl (then part of the Soviet Union). A safety test that went wrong caused two explosions in one of the power station's reactors. The first of these blew the 2,000-tonne roof off the reactor vessel and the second punched a hole in the reactor building. Radioactive substances were released from the reactor almost immediately. The reactor was on fire for ten days. Large quantities of radioactive dust spread across Europe and parts of Asia.

After the Chernobyl accident, public support for nuclear energy declined in the Netherlands (Dekker et al., 2011). The government decided to postpone its plans for new nuclear power stations three times: in 1986, 1988 and 1989. In the 1995 White Paper on Energy Policy, the government then concluded that no new nuclear power stations would be built. However, research into nuclear energy had to be continued.

2.4 Nuclear energy plans at the turn of the millennium

In the 1990s nuclear energy did not feature prominently on the political agenda in The Hague. At the beginning of this century, however, policymakers began to pay renewed attention to the subject. This was



prompted in part by new advice from the General Energy Council and Social and Economic Council (AER, 2008; SER, 2008).³

In view of the urgent climate targets, both advisory bodies highlighted the need for a reassessment of energy policy, giving serious consideration to the option of using nuclear power stations as part of the energy supply. The advice of these two bodies brought about a policy change. In the 2008 Energy Report the government stated that it no longer ruled out the possibility of nuclear energy playing a complementary role within the future energy supply (EZK & VROM, 2010). Nuclear energy was described in this policy document as a possible bridging technology during the transition to an energy system based on renewables.

Shortly afterwards, planning for the expansion of nuclear energy in the Netherlands got under way. Two commercial operators, the energy companies RWE and Delta, submitted proposals for the construction of a new nuclear power station in Borssele.

However, a new nuclear disaster threw an untimely spanner in the works. In March 2011 the nuclear power station in Fukushima, Japan, was hit by a tsunami. The diesel generators used for emergency cooling were flooded by the tidal wave and failed, resulting in insufficient cooling of the nuclear fuel. This was followed by a meltdown in three reactors. Explosions occurred, releasing large quantities of radioactive particles.

The nuclear disaster in Japan again affected support for nuclear energy in the Netherlands, both within society and in political circles (PZC, 2012).

The number of people in favour of building new nuclear power stations fell

³ At the time an insightful fact-finding paper was commissioned by the Social and Economic Council's Future Energy Supply Committee (Scheepers et al., 2007).

sharply.⁴ At the same time, RWE and Delta concluded that their respective business cases for the construction of a new nuclear power station in Borssele were not feasible under the market conditions prevailing at that time. The plans were put on hold (EZ, 2012).

2.5 Focus on nuclear energy in fourth Rutte government

In 2018, relatively soon after the nuclear disaster in Fukushima, the nuclear energy debate was revived in the Netherlands. Various media focused on the subject.⁵

Nuclear energy was back in the news and back on the Dutch political agenda (Tweede Kamer, 2018). Since then it has been regularly debated in the House of Representatives (Tweede Kamer, 2019a, 2020a, 2021a, 2021b). The renewed focus on nuclear energy seems to have led to a shift in the Dutch public's opinion on the subject. The proportion of people who are (moderately) in favour of building new nuclear power stations has grown in recent years.⁶

In 2020, at the request of Parliament (Tweede Kamer, 2020b), the government commissioned a market consultation on nuclear energy (KPMG, 2021). In addition, the government has commissioned a scenario

⁴ In 2010, 34% of the respondents in the National Voters Survey were moderately to very positive about the construction of new nuclear power stations. This contrasts with a figure of just 19% in 2012. See: National Voters Survey 2012 <https://www.cbs.nl/nl-nl/maatwerk/2013/05/resultaten-nationaal-kiezers-onderzoek-2012>

⁵ In the TV programme *Zondag met Lubach* (Sunday with Lubach) on 4 November 2018 Arjen Lubach made a plea in favour of using nuclear energy. Other media also picked up this theme, including current affairs programme *Nieuwsuur* (News Hour). See <https://nos.nl/nieuwsuur/artikel/2258074-dijkhoff-klimaatdoelen-onhaalbaar-zonder-nieuwe-kerncentrales>

⁶ See <https://www.dpes.nl/statistical-analysis/>



study, which is currently in progress, into the role that nuclear energy could play in the energy supply as a complement to other energy sources, such as wind and solar energy. At the request of the House of Representatives, the government has also made a case in Brussels for nuclear energy to be labelled 'sustainable' under the so-called EU taxonomy (Tweede Kamer, 2021c).⁷

On taking office, the fourth Rutte government subsequently declared itself in favour of facilitating preparations for the construction of two new nuclear power stations in the Netherlands:

"Nuclear energy can complement solar, wind and geothermal energy in the energy mix, and can be used to produce hydrogen. It also makes us less dependent on imported gas. The Borssele nuclear power plant will therefore be kept operational for longer, with all due consideration naturally given to safety. The government will also take the necessary steps for the construction of two new nuclear power plants. This means that, among other things, we will assist commercial operators in their exploratory studies, support innovation, carry out tender procedures, consider the contribution (financial or otherwise) to be provided by public authorities, and prepare legislation where necessary. We will also

⁷ The EU taxonomy for sustainable activities classifies the extent to which investments contribute to the sustainability of the European economy and is intended to help investors looking for sustainable investments. The European Commission's proposal to include nuclear energy in the taxonomy temporarily (up to 2045) and subject to specific conditions and transparency requirements (European Commission, 2022) was adopted by the European Parliament on 6 July 2022.

ensure safe, permanent storage of nuclear waste." (Coalition Agreement, December 2021)

Figure 2: Students on climate march in The Hague, 2019: 'Split the atom, or we split the government'



Source: Peter Hiltz / ANP / Hollandse Hoogte

The process to be followed to implement this government proposal is outlined in three government papers (EZK 2022a; 2022b; 2022c). In the first paper the government outlines a future energy system and the complex



tasks that lie ahead as we move towards it (EZK, 2022a). In the second paper (EZK, 2022b) the government explains the steps that will be involved in the decision-making process relating to nuclear energy. This paper stresses the importance of building the necessary knowledge infrastructure, which has previously been assessed as vulnerable (Commissie Van der Zande, 2020). In the third paper (EZK, 2022c) the government proposes to investigate, together with the House of Representatives, whether a citizens' assembly could be established in 2023 to discuss choices associated with the energy transition. Following the guidance of the Brenninkmeijer Committee (Adviescommissie Burgerbetrokkenheid bij klimaatbeleid, 2021), the government lists the following as essential preconditions: (a) a clear and focused question that is urgent and relevant for a broad group, (b) clarity in advance about what will be done with the outcomes of the citizens' assembly and (c) a broadly composed group of participants (achieved, for example, via a weighted lottery) of manageable size. The envisaged number of participants is between 100 and 150.

During the current government's term of office we expect there to be further political and public debate on a number of occasions regarding the possible role of nuclear energy within the Netherlands' future energy system. These moments of debate will often be linked to decisions on important conditions relating to the potential construction of new nuclear power stations. Some examples:

- *Adoption of the National Energy System Plan for 2050.* This plan, which is to include input from an expert team appointed by the Minister for

Climate and Energy Policy,⁸ must provide a greater insight into the desired direction of development of the Dutch energy system. The plan will take the form of a roadmap that can be adjusted along the way (EZK, 2022a). Over time, the form that a fully carbon-neutral energy system will ultimately take must be brought into ever-sharper focus. The adoption of the plan and the accompanying environmental impact assessment, including the possible role of new nuclear power stations within it, is expected to be the subject of debate.

- *Decision-making on financial support for commercial operators with plans to construct a new nuclear power station.* The government has announced its intention to assist commercial operators in their exploratory studies, support innovation, carry out tender procedures and – in contrast to the plans for new nuclear power stations at the start of the millennium – consider financial contributions to be provided by public authorities. A sum of €5 billion has been set aside for this purpose in the coalition agreement. The amount of any financial (and other) contribution and the conditions under which it will be provided are expected to be the subject of debate.
- *Site selection and licensing of a new nuclear power station.* In the Netherlands any commercial operator who meets the relevant legal requirements can apply for a licence to build and operate a nuclear power station. This licence application must be submitted to the Authority for Nuclear Safety and Radiation Protection (ANVS). The application relating to construction must include a safety analysis and

⁸ The Energy System 2050 Expert Team was formally established by the Minister for Climate and Energy Policy on 22 April 2022. See <https://wetten.overheid.nl/BWBR0046613/2022-04-30>



an environmental impact assessment (ANVS, 2021). A decommissioning plan must also be submitted with the application for an operating licence. In addition, a building permit is required (which involves amending the local zoning plan).⁹ As soon as specific sites come under consideration and the licensing procedure gets under way, we expect further political and public debate.

The causes of debate outlined above will not necessarily follow on from each other chronologically. Moreover, in practice, some of them may fail to materialise or new ones may emerge. Past experience also shows that political decision-making on nuclear energy can be erratic – often as a result of unforeseen social developments that influence public opinion. There is an important lesson to be learned from this when it comes to organising decision-making processes relating to nuclear energy (see 2.7).

2.6 Views that repeatedly crop up in the nuclear energy debate

The nuclear energy debate is being conducted from different perspectives. There are supporters and opponents of nuclear energy, as well as a group that adopts a neutral stance towards this issue or still has doubts. As the debate is dominated by those for and against, there seems to be a high degree of polarisation around this topic. However, the neutral group, made

⁹ For three ‘reserved sites’ it has been agreed that no activities should be carried out that would make the construction of nuclear power stations impossible. These sites are: Borssele, Maasvlakte I and Eemshaven. In March 2021 the House of Representatives passed motions calling on the government to remove Eemshaven from this list (Tweede Kamer, 2021a; 2021b).

up of people who have no strong opinion either way, is surprisingly large. Four out of ten Dutch people have no clear position in relation to nuclear energy (Ipsos, 2022a). This large group is not particularly visible in the debate, even though it is decisive in terms of support for an energy system with or without nuclear energy (Vossen, 2019).

To provide an impression of the arguments and opinions that, according to our analysis, play a role in the public debate, in the text boxes below we allow three imaginary people to have their say. What they have in common is that they are all concerned about the climate. However, they have very different assessments of nuclear energy and also differing views on the use of technology to solve the climate problem.

A supporter

Nuclear energy is the best and perhaps the only solution if we want to achieve a responsible energy transition. Just a few nuclear power stations can save us from all kinds of painful measures: no need to cover meadows with solar panels or fill nature areas with wind turbines. Nuclear power stations are good for us and for future generations. Nuclear energy is clean, safe and does not consume many resources. What’s more, the latest generation of nuclear power stations is perfectly safe. Experts have been saying this for a long time. There’s also no problem with nuclear waste: it’s long been clear that we can store it deep underground.

A nuclear power station may not be cheap, but you’d otherwise be spending a lot of money on renewable energy. In the end, it’s well worth



the investment. That's because nuclear energy is reliable. And we need reliability, because it's not always windy and the sun doesn't always shine. Without nuclear energy the lights might just go out at certain times.

By building a few nuclear power stations as soon as possible, you'll resolve a significant part of the energy transition and avoid putting our prosperity and that of our children at risk. With every day that we wait, it only becomes more difficult and more expensive. We should be proud of new nuclear power stations. Nuclear energy offers us hope for a good, sustainable future.

Emotions experienced¹⁰: hope, pride, joy and sense of responsibility

An opponent

We must all act quickly to combat climate change. That means completely overhauling our energy system and reducing our demand for energy. We need to commit fully to wind turbines, solar panels, batteries and hydrogen. If we do that, we won't need expensive nuclear power stations at all. That way we'll end up with a cheaper and more sustainable solution. A system made up of different types of renewable energy sources spread around many different locations is also much more reliable than one consisting of large power stations. Nuclear power

stations should not be part of a modern energy system, as they are far too inflexible.

Nuclear energy can also cause a great deal of damage to people and the environment if it goes wrong. It may not go wrong that often, but when it does it goes badly wrong. For that reason we cannot blindly put our faith in everything being fine when it comes to safety. The consequences of a nuclear disaster are incalculable. Nuclear energy is often referred to as clean energy, but that is incorrect. The waste is certainly not clean. There is no solution to this problem, which means you end up saddling future generations with the danger and pollution. Not to mention the risk of nuclear power stations being used to make nuclear weapons.

Building a few nuclear power stations does not bring about the transition of our entire energy system – much more needs to be done to achieve that. Nuclear energy is an excuse not to have to change and to leave things as they are.

Emotions experienced: hope, worry, sense of responsibility

A doubter

I don't really have a strong opinion about nuclear energy. I'm not sure whether I'm for or against it. The most important thing is to tackle climate change and make sure the electricity coming out of the socket is affordable. Exactly how we do that is less important to me.

¹⁰ Emotions mentioned in this text box and the text boxes below are based on Ipsos (2022a).



A nuclear power station generates a lot of electricity and has hardly any emissions, but it is also not cheap. But if it gives us security for those times when the sun doesn't shine and the wind doesn't blow, perhaps it is worth it, or are there other ways to get affordable power in such situations? I don't like the idea of nuclear waste and we'll have to find a good solution to this problem. I'm confident that it's safe, although I'd like to know more about what the dangers are exactly. We need to leave this country in a good state for our children.

Emotions experienced: hope, worry, sense of responsibility

As the examples illustrate, people who see a role for nuclear energy argue that nuclear power stations are *clean, safe* and *reliable*. These are arguments that repeatedly crop up in the debate. People who reject nuclear energy take the view that nuclear power stations are *expensive, polluting* and *unsafe*. These arguments, too, have been put forward for decades.

It is striking that supporters and opponents also experience differing emotions. While *hope, pride* and *joy* predominate among supporters of nuclear energy, *anger, fear* and *worry* are the dominant emotions among opponents. Both groups feel a sense of *responsibility* for preventing climate change.

2.7 Lesson: diligent and transparent decision-making is necessary

If the history of nuclear energy in our country tells us anything, it is that people are not indifferent about this subject. Moreover, public opinion in this area is highly volatile. Every time there is a nuclear accident somewhere in the world, regardless of the scale, emotions run high and public support for nuclear power stations largely evaporates. What is also striking is that, as a result of this situation, Dutch policy on the use of nuclear energy has been anything but stable in recent decades. This is an important observation in view of the current situation, in which a stable energy policy is essential to keep the 2050 climate targets within reach. Such a loss of support can also be seen in relation to other aspects of the energy transition, such as the installation of onshore wind turbines, the use of biomass for electricity generation and underground carbon storage. This lack of backing for all kinds of potential changes to the energy system only increases the risk of failing to achieve the climate targets on time.

The question is how can we prevent political decision-making in the area of nuclear energy from remaining as erratic – under the influence of public opinion – as it has been in recent decades. At the very least decisions need to be made diligently and transparently. Research shows that the way decision-making procedures relating to such issues are structured affects citizens' acceptance of government decisions that do not correspond to their own preferences. Decisions are more likely to be accepted if citizens think the procedure followed to arrive at the decision was just (Krütli et al., 2015).



When do people experience decision-making procedures as just?

A number of conditions contribute to a decision-making procedure being experienced as just:

- It must be possible to participate in the decision-making in an accessible way.
- There must be clear criteria for determining who has a say and a right to be present in the process as a legitimate stakeholder and interested party.
- There must be trust in the decision-maker.
- There must be open and honest communication, good information and explanations about the course and outcome of procedures.
- Decisions should be explained clearly.

Sources: Milchram et al., 2018; Velthoven, 2011; Bies & Moag, 1986.

The quality of decision-making can be improved if the process is designed in such a way that citizens' views form an integral part of it. Aspects that are important to citizens must be taken into account seriously, visibly and comprehensibly. If this is done in a convincing way, we expect it to enhance the justice of the decision-making process and how it is perceived within society (Thibaut & Walker, 1975; Velthoven, 2011). On the other hand, taking citizens' views into account in an ill-considered way could be counterproductive.

The incorporation of citizens' perspectives should not be limited to conventional public participation in formal procedures. Such procedures

often concern sub-topics in which the values that are relevant for citizens barely play a discernible role. When people feel that their concerns are not being sufficiently taken into account by the government's policy choices, or when certain groups within society are unable to participate, this can lead to controversies, to the reversal of policy decisions and, ultimately, to the failure of major energy projects (Adviescommissie Burgerbetrokkenheid bij klimaatbeleid, 2021; Pesch et al., 2017).

What exactly are the values surrounding nuclear energy that are relevant for citizens and should therefore be included in decision-making? What views and emotions play a role in this respect? These questions are addressed in more detail in Section 3.





3 ROLE OF ETHICAL VALUES IN THE CONSIDERATION OF NUCLEAR ENERGY

Nuclear energy is a subject about which many people have an opinion and that is highly emotive for various reasons: concern about climate change, the risks of nuclear accidents, the impact on their own finances, and so on. These considerations and emotions may be an indication of important ethical values (Roeser, 2018). Political decisions should be taken on the basis of values that society considers essential (WRR, 1994; Rli, 2014; Roeser, 2018). 'Ethical reflection' is therefore important before decisions are made on controversial issues. This also applies to a topic such as nuclear energy. In this section we discuss the five ethical values that most people consider important when it comes to nuclear energy. These are values that are just as important within the context of the Netherlands' overall energy system.

3.1 Ethical reflection as part of the energy debate

In the public debate on nuclear energy sentiments can run high. The picture that we often see is one in which non-expert participants in the debate react emotionally, while experts rely on 'facts': quantitative data on the risks (probability of accidents, environmental impact) associated with nuclear

reactors. Policymakers sometimes tend to ignore emotional reactions from the public and listen mainly to experts.

However, experts make choices too. Even quantitative approaches are not necessarily value-neutral, for example. After all, behind every decision about what is worth including in a quantitative risk assessment there is a value judgement. When assessing safety and security, for example, should we only consider human casualties, or also the impact on animals and the environment? Moreover, a quantitative approach to nuclear energy leaves many ethical aspects out of the equation, such as the question of whether everyone in society will benefit equally from nuclear energy, or to what risks it is acceptable for people to be involuntarily exposed.

Because of such limitations of quantitative approaches, in recent years various ethicists have argued that good decision-making on nuclear energy also requires *ethical reflection* on the values that matter to people when it comes to the use of this risky technology.¹¹

What do we mean by ‘values’ and ‘ethical reflection’?

Values indicate what a person strives for or considers important, e.g. equality, sincerity, justice. Values guide our actions. In the case of ‘public values’ they are a collective notion of what is important for society. Values in themselves are rather abstract. To give them concrete form, we have to operationalise them by means of *norms*: the rules that tell us what we have to or are allowed to do in a specific situation. If there is a debate, it is usually at the level of norms.

¹¹ See Section 2 of Part 2 of the Dutch version of this advisory report for a more detailed explanation of the role of values and ethical reflection in the consideration of nuclear energy.

‘Ethical reflection’ means: systematically thinking about values and norms. In relation to nuclear energy, ethical reflection involves, for example, studying and analysing the question of whether using this form of energy generation is desirable within our energy system, what values are relevant when answering this question and how these are prioritised relative to each other when it comes to formulating concrete norms. This can then lead to a judgement about the right thing to do. When there is a conflict of values, with a choice in favour of one value being at the expense of another, we talk of a moral dilemma. Ethics then requires us to make trade-offs: which values do we consider to be the most important?

3.2 Five core values for decision-making on nuclear energy

There are five values that are crucial for ethical reflection on the role of nuclear energy within the Dutch energy system (Taebi & Kloosterman, 2008; Roeser, 2011; Taebi et al., 2012; Taebi & Roeser, 2015). These are: energy supply certainty, affordability, safety and security, sustainability and justice. We briefly explain the meaning of these five values below (see also Section 2 of Part 2 of the Dutch version of this advisory report):

- *Energy supply certainty*¹² is about the extent to which citizens and businesses can be confident that enough energy will be available to them.

¹² Instead of ‘energy supply certainty’ we could also have referred to the more common ‘energy security of supply’. However, because we already use the term ‘security’ when referring to the value ‘safety and security’, we opted for the term ‘certainty’ in relation to energy.



- *Affordability* is about the extent to which the costs of the energy system and the way they are passed on (to individual energy consumers and to society as a whole) are acceptable.
- *Safety and security* is about the extent to which it is ensured that any damage to human health, the economy and/or ecology that may occur as a result of accidents or deliberate actions remains within manageable proportions.
- *Sustainability* is about the extent to which the impact of different energy sources on the environment, nature and the climate is acceptable.
- *Justice* has a different status and involves two questions: (1) the extent to which *decision-making* about the energy system is fair and transparent (see also 2.7), and (2) whether the *benefits and burdens are distributed fairly* between groups within society, between countries and between current and future generations. *Procedural justice* can be seen as an overarching value, as it concerns the transparency and fairness of the procedures used to implement the other values. *Distributive justice* is about distributing the outcomes of the other values (energy supply certainty, affordability, safety and security and sustainability) across groups of people.

These five values play a key role in the public debate. They are all values that touch on what is really important to people. This explains the often emotional reactions that nuclear energy evokes in people (Steg et al., 2021; Perlaviciute, 2019; Perlaviciute et al., 2021).¹³ There is a high degree

¹³ Nuclear energy evokes very different emotions among supporters and opponents, as described under 2.6 in Section 2 and as shown by research we commissioned into the factors that play a role in shaping the Dutch public's opinion about nuclear energy (Ipsos, 2022a); see Section 4.

of consensus among experts about the relevance of these five values in relation to nuclear energy, as became apparent in a meeting that we organised as part of this advisory process.¹⁴ The five values also found favour in thematic expert meetings and discussions we held with various stakeholders.¹⁵

All this does not mean, however, that people assess these values in the same way. For example, whether or not nuclear energy is sustainable is certainly not an uncontroversial question. Nor is there any consensus or objective truth regarding what is or what is not a just distribution of benefits and burdens. In addition, people also prioritise the values differently. While sustainability is crucial for some, energy supply certainty is more important for others.

These five values form the basis for the rest of this advisory report (see Figure 3). In Section 4 we consider citizens' views on nuclear energy on the basis of these five values. In Section 5 we examine, on the basis of technical scientific research, what factual information is available about the characteristics, opportunities and risks of nuclear energy for each of the five values.

¹⁴ On 28 September 2021 we organised a meeting with a broad group comprising around 60 experts and stakeholders from civil society organisations, the nuclear industry and the scientific community, as well as other interested parties. See <https://www.rli.nl/consultatie-kernenergie/startbijeenkomst-28-september-2021-informatie>

¹⁵ The expert meetings revealed, however, that the participants attached varying levels of importance to the values and interpreted some values differently. For more information about these expert meetings, see the appendix.



Figure 3: Five values for ethical reflection on nuclear energy



4 CITIZENS' VIEWS ON NUCLEAR ENERGY

The quality of decision-making on nuclear energy will benefit from serious consideration of the aspects that citizens see as important. This means that an open debate on nuclear energy is needed – one in which attention is given to and space created for the opinions and emotions surrounding nuclear energy, all of which touch on the five values discussed above: energy supply certainty, affordability, safety and security, sustainability and justice. But what exactly are people's opinions and emotions when it comes to nuclear energy? How much do they vary within society? And to what extent is the war in Ukraine affecting what people think about nuclear energy? These questions are addressed in this section, drawing on media reports, scientific publications, the results of meetings and expert opinions. In addition, we asked the market research agency Ipsos to conduct a public survey for us into the factors that play a role in shaping the Dutch public's opinion of nuclear energy (Ipsos, 2022a).¹⁶

¹⁶ The Ipsos survey is being published at the same time as this advisory report. The survey provides an impression of the various associations, emotions and arguments that come into play when citizens express their views on nuclear energy. See also the explanation of the survey in Section 1 of Part 2 of the Dutch version of this advisory report.



4.1 Citizens' views on nuclear energy before and after the start of the war in Ukraine

In December 2021 we asked Ipsos to measure what the Dutch think about nuclear energy in general and specifically about whether the government should encourage the construction of two new nuclear power stations in our country.

The measurement was carried out before Russia invaded Ukraine in February 2022. Since then the Netherlands, like the rest of the EU, has had to deal with stagnating imports of Russian natural gas. This has led to citizens becoming increasingly concerned about the energy supply in the Netherlands. They are asking themselves questions such as 'will we soon be left in the cold?' and 'shouldn't the Netherlands take urgent steps to become self-sufficient?'. Against this background the proportion of people in favour of nuclear energy and new nuclear power stations might be expected to increase further. Has that actually happened?

To find out whether the war between Russia and Ukraine has influenced public opinion in the Netherlands about the energy supply, we asked Ipsos to measure the opinion of the Dutch public regarding nuclear energy and the construction of new nuclear power stations again in May 2022 (Ipsos, 2022b). The results of both measurements are shown below.

Table 1: Opinion on nuclear energy before and after the start of the war in Ukraine (p=0.06)¹⁷

	In favour	Neutral	Against	Total
First Ipsos measurement (December 2021)	40%	38%	22%	100% 1,523
Second Ipsos measurement (May 2022)	44%	36%	19%	100% 1,033

Table 1 shows that within our society there is a relatively large group of people who are neutral towards nuclear energy. This has hardly changed since the outbreak of the war in Ukraine; initially this group comprised 38% and subsequently 36% of the respondents. The proportion of people who oppose nuclear energy appears to have decreased slightly in the May 2022 measurement (i.e. after the outbreak of the war in Ukraine), falling from 22% to 19%. The percentage of people who support nuclear energy has risen slightly from 40% to 44%.

The war in Ukraine seems to have significantly shifted public opinion in particular on encouraging the construction of new nuclear power stations; see Table 2. The percentage of respondents who were against promoting nuclear energy dropped from 27% to 18% in the second measurement (i.e. after the outbreak of the war). A much larger proportion of those questioned are now neutral; this percentage increased from 33% to 41%.

¹⁷ The p-value is a number between 0 and 1, where a p equal to or less than 0.05 is usually considered to be statistically significant.



Our conclusion in Section 2 that events elsewhere can have a major influence on what people in the Netherlands think about new nuclear power stations seems to be confirmed by these results.

Table 2: Opinion on the Dutch government actively encouraging the construction of new nuclear power stations, before and after the start of the war between Russia and Ukraine (p=0.00)

	In favour	Neutral	Against	Total	
First Ipsos measurement (December 2021)	40%	33%	27%	100%	1,523
Second Ipsos measurement (May 2022)	41%	41%	18%	100%	1,033

4.2 Citizens' opinions on the five values

We now have a general impression of what the Dutch think about nuclear energy. Based on the five values that define the nuclear energy debate (energy supply certainty, affordability, safety and security, sustainability and justice), we have examined the arguments, opinions and emotions that lie behind these views. The results are summarised below.

Opinions and emotions associated with energy supply certainty in relation to nuclear energy

The public debate on nuclear energy that plays out in newspapers, on television, in scientific publications, at local consultation meetings, in the House of Representatives, and so on, often deals with the contribution that nuclear energy could make to our country's energy supply certainty in the future. This aspect of the energy transition is a matter of concern for many people. They are worried about the reliability of future energy supplies. Will the Netherlands manage if we only generate energy from wind, sunlight and other renewable sources?

More than half of people see nuclear energy as unavoidable in view of the level of energy demand

The Ipsos public survey asked questions about energy supply certainty and how people view the role of nuclear energy against that background. Opinions differ on this. Some respondents see nuclear energy as the solution to the climate problem, precisely because it guarantees the availability of electricity. Others do not believe nuclear energy is necessary to increase energy supply certainty and would prefer an energy system based on renewable energy sources.

For a large group of 53% nuclear energy is necessary for the Netherlands to have sufficient energy. We will return to this topic in Section 5.



Opinions and emotions associated with affordability of nuclear energy

The aspect of 'affordability' frequently crops up in the political and scientific debate on nuclear energy. Here the focus is not only on the costs of (constructing and operating) individual nuclear power stations, but also on the impact of nuclear energy on the costs of the energy system as a whole. After all, to put the affordability of nuclear energy into perspective, estimates are also needed of the construction and operating costs of other components of our future energy system, such as the installations, networks and storage capacity required for wind energy, solar energy and hydrogen. The pricing of energy is therefore extremely complex and difficult for the general public to understand.

Nevertheless, the affordability of energy is of great concern to citizens, as high energy prices have a direct impact on all our lives. The Dutch have become accustomed to relatively low energy prices in recent years. This situation changed dramatically from autumn 2021 onwards due to a combination of causes. Since then many energy consumers have seen their energy bills double or even triple. 'Energy poverty' is therefore a growing problem in our society. Many people are extremely worried about it and afraid of their financial situation becoming worse.

Most people do not know whether nuclear energy is expensive or cheap

In our survey we asked questions about the costs and affordability of the Dutch energy system with and without nuclear energy. Twenty-seven per cent of the Dutch population think nuclear energy is expensive, while 22% think it is not. The majority (51%) do not know. At the same time, 54% expect their energy bills to increase without nuclear energy (Ipsos, 2022a).

Opinions and emotions associated with the safety and security of nuclear energy

In the public debate on the safety and security of nuclear energy there is a significant difference between the perspective of the government and the nuclear sector, on the one hand, and the opinions held within society, in particular by people who are concerned about nuclear energy, on the other.

The government's perspective is centred around safety guarantees. The nuclear energy sector is subject to strict (national and international) supervision. This applies both to the power stations themselves and to the fuel and waste processing chains. Regulation, supervision and the safety culture around nuclear energy are highly developed. The focus of government policy is therefore on minimising the *probability* of damage. On the other hand, some members of society are concerned about the risks associated with nuclear energy. Most citizens know that strict safety measures apply to nuclear power stations and that the *probability* of accidents is very low. Nevertheless, many people are worried. They focus



in particular on what the consequences will be if something does happen to go wrong and point to the expected *effects* of an incident or accident involving a nuclear power station or the storage of nuclear waste.

The government and society also have differing assessments when it comes to the impact of a nuclear accident. Government policy assesses the impact of a nuclear accident on the basis of its radiological consequences, while for many citizens panic and social disruption are also part of the impact. When estimating the impact of a nuclear accident, fear of deaths and deformities, including a long distance from the scene, is a much more prominent concern among citizens than in the adopted risk policy. In addition, many people fear that an area around the site will be inaccessible for a long period of time after an accident involving a nuclear power station (RIVM, 2016; RIVM, 2018; Dekker et al., 2011).

This difference in focus, on either the low probability or the significant impact of nuclear accidents, complicates the discussion about the safety of nuclear energy. One important aspect in this regard is the confidence people have in the extent to which risks can be managed (Hintum, 2019).

Our public survey reveals that the aspect of safety weighs heavily in people's judgements about nuclear energy; see box. We see this as an important consideration for the government in future decisions on nuclear energy.

safety and security is seen as important, but opinions are split about the risks

The Ipsos public survey (2022a) shows that safety and security considerations have the greatest impact on people's opinions about nuclear energy. However, there are conflicting views on its overall safety and security. For example, 40% of Dutch people agree with the statement 'Nuclear energy is safe, because the probability of accidents is low', while 26% disagree. At the same time, 36% agree with the statement 'Nuclear energy is unsafe, because a nuclear power station could be the target of a terrorist attack', while 26% do not. Furthermore, 46% of Dutch people agree with the statement 'Nuclear waste constitutes too great a risk'. This is striking, considering that less than 23% of the Dutch population explicitly opposes nuclear energy.

Opinions and emotions associated with the sustainability of nuclear energy

To what extent can a choice in favour of nuclear energy be considered a 'sustainable' choice? This question also plays a role in the public debate on the possible future role of nuclear energy in our country. Supporters of nuclear energy believe it is 'clean' and 'sustainable' because of the *small amount of CO₂* that is released with this form of energy generation. The view that nuclear energy leads to low CO₂ emissions is undisputed, even among opponents.

Sustainability, however, encompasses more than just the absence of CO₂ emissions. The extent of the *impact on the environment and/or nature* also



determines the sustainability of energy generation technologies. When it comes to nuclear energy, nuclear waste is a topic on which opinions are more divided in this regard. Many Dutch people are not convinced that nuclear waste can be stored without negative consequences for the environment and nature.

Many people are worried about the long-term effects of storing nuclear waste

According to our public survey, many people see nuclear energy as unacceptable as long as the waste problem has not been adequately resolved and is thus simply being passed on to future generations. Thirty-six per cent of Dutch people somewhat agree or entirely agree with the statement that we are saddling future generations with too great a risk by using nuclear energy, while 28% disagree. Even those who say they are in favour of nuclear energy acknowledge that nuclear waste is a problem, although they often have more confidence in technological progress and assume that suitable solutions will be developed (Ipsos, 2022a).

Then there is the question of *resource consumption*, which, as with many other energy sources, is also an issue in the case of nuclear energy generation. Can we talk about sustainable energy generation when a finite resource such as uranium is being used for this purpose? Opinions are divided on this question. Some people point out the harmful effects of mining. In certain cases the extraction of uranium is seen as objectionable

in particular because we are using up reserves of raw materials that future generations may need.

Opinions and emotions associated with a just distribution of the benefits and burdens of nuclear energy

Questions relating to distributive justice crop up in various ways in the public debate on the possible role of nuclear energy within the energy transition.

A first topic of concern is the choice of sites for the construction of nuclear power stations and the storage of nuclear waste. Here we see a reaction within society that often occurs when space is needed for controversial activities: people widely recognise the importance of the activities, but if these activities are planned for their own local area, they are more critical in their judgement. People therefore explicitly consider the impact that the activity has on them personally. If people experience a disproportionate accumulation of burdens, this can reinforce a negative response. This is the case in the province of Groningen, for example, which is suffering from earthquakes as a result of natural gas extraction. As a result, two motions were tabled in the House of Representatives to remove Eemshaven as a possible site for new nuclear power stations (Tweede Kamer, 2021a, 2021b).

Distributive justice is also an issue for people when it comes to the question of how to divide up the costs of building one or more potential new nuclear power stations. Which part will be paid by energy companies (and charged via energy bills) and which part will be paid by the government (and charged via taxes)? This distribution matters, because when energy costs



are passed on via energy bills, people on low incomes are hit harder than when they are passed on via taxation.

Finally, the Ipsos survey reveals that many people think it is important that the benefits of nuclear energy for our generation (clean energy at acceptable prices) are properly balanced against the burdens that future generations may face (climate change, nuclear waste, depletion of uranium reserves).

4.3 Interpreting the five values in decision-making

The Dutch have very different opinions about nuclear energy and it is clear from the above that all manner of aspects influence the way they think. Differing views are held about other energy sources too. Nevertheless, the Dutch are most divided when it comes to nuclear energy. In the first Ipsos measurement participants were asked to rank seven different energy sources from 'most wanted' to 'least wanted'. Twenty-four per cent of the respondents picked out nuclear energy as their favourite, while 21% regarded it as the least desirable energy source. None of the other energy sources showed such a wide range of preferences (Ipsos, 2022a).

The Dutch have concerns about many different aspects of nuclear energy. Various considerations come into play here; these may point to important ethical values that should be made explicit and form the subject of social decision-making. By making these considerations explicit and involving citizens in the decision-making process relating to nuclear energy, the

government can do justice to society's concerns more effectively. This is crucial if we are to achieve a stable, 'durable' nuclear energy policy that enjoys sufficient support within society.

According to the Ipsos public survey, many citizens have little confidence in the government on the subject of nuclear energy, but nevertheless expect a lot from that same government. Only 31% of the population say they have confidence in the government when it comes to nuclear energy. At the same time, 78% say that the government should take the lead in combating climate change. This means the government needs to carry out its role carefully.

It is important that the five values that are important to citizens when it comes to nuclear energy – energy supply certainty, safety and security, affordability, sustainability and justice – are made *explicit*. These values will need to be explicitly considered as part of the decision-making process on nuclear energy. This could be done by posing questions such as: "When will we consider the energy supply to be safe?"

In the choices to be made relating to the future energy system, thinking explicitly about trade-offs between *values* is also of great importance. To this end, questions such as the following should be considered: "Do we want our energy supply to be more secure or cheaper?" or "Are we prepared to accept more wind turbines in our environment, in combination with hydrogen storage in salt caverns, if by doing so we can rule out the



risk of a nuclear accident and avoid burdening future generations with the disposal of nuclear waste?”

It is often thought that it makes no sense to include these kinds of questions and considerations in the debate, because no consensus can be reached on values (and the associated emotions). However, many values (including the five that are central to this advisory report) and many emotions are actually tacitly shared. Even if they only exist among certain social groups, emotions can point to underlying ethical aspects that need to be explicitly discussed if issues are to be considered in a well-informed way (Nihlén Fahlquist & Roeser, 2015; Roeser & Pesch, 2016; Roeser, 2018).¹⁸ As we explained in Section 3, we therefore believe that there should be more scope for ethical reflection both in the decision-making process relating to nuclear energy and in the preceding debate.

¹⁸ Not all emotions are equally helpful; they can also be an indicator of misunderstandings and prejudices (Steinert & Roeser, 2020).





5 PERSPECTIVE ON THE FIVE VALUES BASED ON EXISTING KNOWLEDGE

In the previous section we used five values that define the public debate on nuclear energy (energy supply certainty, affordability, safety and security, sustainability and justice) to illustrate what Dutch people think about the future role of nuclear energy and the arguments they use. In this section we consider the arguments arising from the public debate objectively by assessing them against (a) technical scientific knowledge about the role of nuclear energy within the energy system and (b) insights from the field of ethics. We examine what factual information is available in the literature regarding the characteristics, opportunities and risks of nuclear energy, taking the five values as a yardstick. Are the views of the Dutch public consistent with the facts? Are some arguments demonstrably wrong? Are there perhaps certain subjects that are not covered in the debate on nuclear energy, but that are nevertheless relevant? What ethical questions does this raise?

5.1 Energy supply certainty

To what extent will nuclear energy be necessary in the future to guarantee the Netherlands' energy supply certainty? To answer this question, we looked at the literature to see what is known about the reliability of the

current energy supply and about the changes that are expected as a result of the energy transition.

Reliability of energy supply

The Netherlands has a very reliable electricity system. There is almost 100% year-round availability of electricity for both households and businesses (TenneT, 2020). This is in line with the high norms that we have set for our energy supply as a society. But will that remain the case in the future? It is possible that the energy transition will lead us to reconsider these norms. Ensuring a similarly high degree of reliability during and after the transition will be a major challenge. After all, in the near future we will be using much more electricity: to power electric cars, to heat homes and buildings via heat pumps, to drive production processes in factories, to produce hydrogen for making synthetic fuels, and so on.

This development will greatly increase the share of electricity within the energy system. Research by TNO (Scheepers et al., 2020) reveals that the demand for electricity will at least double and possibly triple by 2050.¹⁹ This will clearly have a major impact on the requirements that the future energy system has to meet. The electricity infrastructure will need to be

¹⁹ The contribution that a nuclear power station can make to meeting this doubled or tripled energy demand depends on a number of factors. In absolute numbers, doubling or tripling demand means that 240 TWh to 360 TWh of electricity is required (compared to the current 120 TWh). A generation III(+) nuclear power station with a capacity of 1,000 to 1,600 MW can generate 8 to 12.8 TWh of electricity per year at maximum operation (about 8,000 hours per year). Provided that market conditions allow a nuclear power station to operate at full capacity, one nuclear power station could therefore meet several per cent of the total future demand for electricity. If there are two or more nuclear power stations, this share increases rapidly: ten nuclear power stations could meet one third of total future electricity demand.

upgraded. Furthermore, solutions will need to be found to cope with the weather-dependent fluctuations in the energy supply. It is government policy that by as early as 2030 at least 70% of the electricity generated in our country will come from wind turbines and solar panels. In terms of the energy supply, there will therefore be differences between days when there is a lot of and days when there is little wind and/or sunlight, and also between day and night and summer and winter. An important question is therefore: how do we ensure that, in the energy system of the near future, supply and demand are matched at all times of the year? Supply and demand will need to be balanced on an ongoing basis at the level of: (a) seconds and minutes, (b) hours and days and (c) seasons.

As part of the search for solutions, the energy sector is considering how to organise *flexibility in the electricity system* (Topsector energie, 2018). In concrete terms, such flexibility can be achieved through a combination of:

- dispatchable power generation capacity, e.g. rapid-deployment, hydrogen-based gas-fired power stations;
- energy storage options, such as batteries, underground hydrogen storage, heat storage;
- conversion of electricity to heat (using e-boilers or heat pumps), hydrogen and other compounds (such as ammonia or methane);
- construction of cross-border electricity interconnectors for imports from and exports to other countries; and
- energy demand management (for example, by managing the charging of electric car batteries and the feeding of energy from them back to the grid, and by getting people to turn down their thermostat).



The question now is: to what extent could nuclear power stations contribute to the above ways of introducing flexibility into the energy system or reduce the need for such measures? Technically speaking, there are several possibilities. To begin with, energy generation from nuclear power stations can be controlled at the level of hours and days and at the level of seasons. Depending on their design, nuclear power stations can even offer flexibility in the energy supply at the level of minutes.²⁰ Furthermore, at times when they do not need to supply electricity, nuclear power stations can contribute to the flexibility of the energy supply by producing high-temperature heat or hydrogen. There are, however, costs associated with using nuclear energy for these purposes (see 5.2 below on affordability). We must therefore ask the following question: to what extent is using nuclear energy to increase the flexibility of the energy supply necessary and thus unavoidable?

Need for nuclear energy to achieve a flexible energy supply

In recent years scientific studies have been conducted into the future carbon-neutral energy system in the Netherlands. Some of these do not include nuclear energy (e.g. CE Delft, 2017; Berenschot, 2021; TNO, 2020), while other studies do (Zappa, 2019; Berenschot & Kalavasta, 2020; Fattahi

²⁰ In accordance with current requirements, nuclear power stations need to be able to adjust between 50% and 100% of their capacity twice a day within 15 minutes (European Utility Requirements, 2012). For several decades France has had reactors that can switch from 20% to 100% of capacity and back again within half an hour. This is more than enough to follow the day-night rhythm of electricity demand in the current system (Kloosterman, 2019). However, there are alternatives with even more favourable ramping rates. The flexibility of nuclear power stations is similar to that of coal-fired plants, but lower than that of some gas-fired plants (OECD, 2012). See OECD NEA (2011) for more information on technical and economic aspects of using nuclear power stations to achieve a flexible supply of electricity.

et al., 2022; Scheepers, 2022). Although the studies show that nuclear energy is not necessary to achieve a flexible energy supply, they also make it clear that if the government abandons nuclear energy, this will have consequences for freedom of choice when it comes to how the flexibility of the energy supply can be realised. In such a case a greater emphasis will be placed on the use of biomass and natural gas (with carbon capture and storage), energy demand management, electricity storage in batteries, conversion of electricity to hydrogen, energy imports and the construction of electricity interconnectors with other countries.

Conversely, using nuclear energy to make the energy supply more flexible also has consequences, from a financial and economic perspective and in terms of the infrastructure required. Interested commercial operators require substantial financial guarantees from the government to build new nuclear reactors. Otherwise they would consider the investment too risky (KPMG, 2021). If nuclear energy is used to create more flexibility in the energy system, this therefore calls for a different (more directing or interventionist) role on the part of the government (see also 5.2 below). In addition, major changes to infrastructure are needed to ensure that, at times when there is a sufficient supply of energy, the energy generated by the nuclear power station can be used to produce hydrogen or heat, which is then transported.

One of the advantages of focusing on nuclear energy is that it increases the range of options. After all, there is a fair amount of uncertainty associated with realising the energy transition. The necessary innovation and upscaling



may not always go according to plan due to technological setbacks, procedures that cause delays or policy changes. By targeting a broad range of energy generation technologies, a more robust transition path could be created that provides greater certainty that a constant supply of energy will be guaranteed.²¹ In this way, nuclear energy has an *option value*: if other technologies unexpectedly fall behind, nuclear energy can then step in. A limiting factor in this regard is that nuclear power stations have a long preparation and construction time. An important condition for preserving the option value is therefore that the government is prepared to facilitate the possible realisation of nuclear power stations and that construction starts on time. In any case, it is clear that various social advantages and disadvantages are attached to the different options and also require ethical consideration.

5.2 Affordability

Is nuclear energy more expensive or cheaper than other energy generation technologies? Is there an additional cost attached to the use of different energy sources? We examined what answers the scientific literature has to these questions.

Impact of nuclear energy on national energy transition costs

To compare the costs of energy generation technologies, the literature usually looks at the total costs of plant construction and operation,

²¹ Similarly, the robustness of the energy system is also determined by the balance between centralised and decentralised energy generation. Nuclear energy is seen as a technology that belongs to a more centrally organised system, while some people believe that a high degree of decentralisation leads to greater robustness.

distributed over the entire life cycle and expressed in euros per megawatt hour (€/MWh). The cost of nuclear energy from new power stations in the Netherlands is estimated to be between €65 and €120 per MWh.²² This wide spread is due to differences in expected operation (hours per year) and to differences in the construction costs (which can vary depending on the level of interest on the loan that an electricity producer takes out to finance the project). By way of illustration, the Borssele nuclear power station, the cost of which has now been recovered, generates electricity at around €45/MWh, while the cost of electricity that will be generated by the new British nuclear power station Hinkley Point C is expected to be around €110/MWh.

Although the spreads in the costs make a direct comparison difficult, sustainably generated electricity with costs – in the Netherlands – of approximately €50/MWh (for offshore wind), €40 to €70/MWh (for onshore wind) and €50 to €80/MWh (for solar farms)²³ appears to be cheaper than electricity from newly built nuclear power stations. However, this is partly because this standard approach does not include all costs. The additional costs of grid upgrades and flexibility are not taken into account, for example. These costs need to be factored in to allow a fair comparison to be made. It is important to look at the *whole* energy system before assessing whether a system with or without nuclear energy is or is not more expensive.

²² Zwaan (2019) based on Gamboa Palacios & Jansen (2018) and IEA & NEA (2015).

²³ Source: <https://windopzee.nl/onderwerpen/wind-zee/kosten/kosten-windparken/>. Costs have fallen dramatically over the past decade and will continue to fall until 2030 (Algemene Rekenkamer, 2018).



In order to be able to estimate the costs of energy systems with and without nuclear energy, we compared a number of studies. This revealed that there is a wealth of information available that could be used to support policy choices, but also that weighing up all the information properly is no easy task (see Section 3 of Part 2 of the Dutch version of this advisory report for an overview of the studies and our analysis of them).

There are a number of similarities between the studies. All of them conclude that a system with a high degree of variable electricity generation from wind and sunlight requires greater investment both in the grid (upgrading the energy infrastructure) and in flexibility (coping with fluctuations in the energy supply). This applies to energy systems both with and without nuclear energy, although the differences in national costs²⁴ between systems 'with nuclear energy' and 'without nuclear energy' are smaller than the aforementioned prices in €/MWh would suggest (see Section 4 of Part 2 of the Dutch version of this advisory report for an explanation of costs and construction times of nuclear power stations).

However, due to differences in underlying assumptions, the studies reach different conclusions on the national costs of the electricity supply. In most studies the costs are lower in an energy system with nuclear energy, in other studies they are the same, and in a few cases they turn out to be higher than in systems without nuclear energy.

²⁴ 'National costs' are the costs of integrating nuclear energy technology within the existing system of energy technologies. They include (a) the costs of coping with fluctuations and uncertainties in electricity generation and (b) the costs of connecting to the electricity grid and making the necessary adjustments to it (Cometto et al., 2019).

A closer comparison of the studies shows that, due to uncertainties in the researchers' assumptions, the calculated costs have large margins of uncertainty. As a result, the calculated differences in costs between energy systems with and without nuclear energy are no longer significant. Assumptions made in the studies (e.g. relating to the construction time or construction costs of a nuclear power station) also appear to be value-laden to some degree, due to the substantial differences between the studies (see Section 2 of Part 2 of the Dutch version of this advisory report for an explanation of the role of values in technical scientific research). Furthermore, it is not sufficiently clear whether the results of the studies carried out also apply to the Dutch situation. Further research is therefore required. At the moment, we think it makes sense for the government to work from the assumption, when preparing policy, that the national costs of the energy transition with and without nuclear energy are more or less comparable.

Is nuclear energy viable under current market conditions?

Whether nuclear energy reduces national costs is important to society, but not to investors. For energy producers considering investing in the construction and operation of a nuclear power station, the most important question is whether there is a viable business case for nuclear energy. A market consultation study by KPMG (2021) revealed that this is not the case. Commercially, the construction and operation of a nuclear power station is only attractive to private investors if the government provides



ample (financial) support and guarantees.²⁵ This has to do with the way the electricity market is organised in the Netherlands. Under the Dutch market model in its current form, newly constructed nuclear power stations can only be used for electricity generation for a limited number of hours per year (TenneT, 2021).

Current organisation of the Dutch electricity market limits the deployability of nuclear power stations

In the Netherlands the generation and supply of electricity are strictly separated from transmission and distribution. The former are carried out by energy companies (companies in competition on the free market) and the latter by grid operators (state-owned companies with a national or regional monopoly).

On the Dutch electricity grid the grid operators apply the ‘merit order’ principle, which means that energy companies have to use their generation capacity (wind turbines, solar panels, gas-fired power stations, coal-fired power stations, etc.) in a particular order, which is mainly determined by the cost of energy generation. In accordance with this principle, priority is therefore given to producers with the lowest electricity price. This means that, under current Dutch market conditions, nuclear power stations cannot operate continually throughout the year.

To make it attractive for commercial parties to invest in new Dutch nuclear power stations, market interventions will be necessary. These could include price guarantees per kWh generated, arrangements under which nuclear energy is prioritised on the grid (‘must-run’ arrangements) or the use of nuclear energy for purposes other than electricity generation, such as the production of heat and/or hydrogen. The Netherlands could look to the United Kingdom for a further-reaching form of market intervention.

Investment in British nuclear power stations made attractive through market intervention

The market model in the United Kingdom is broadly similar to the Dutch model. However, a change has been made in the way nuclear energy is dealt with. The Hinkley Point C nuclear power station that is currently under construction is supported by price guarantees. There is also a guaranteed return on capital for the newly planned Sizewell C plant. The British government is thus asking the end users of electricity to bear the costs of what it considers to be a more robust energy system. Nuclear power stations are not viewed merely as a regular source of energy, but as ‘essential infrastructure’ – just like drinking water treatment plants, for example. Commercial operators active in the Netherlands say that they consider this model a very attractive way of financing nuclear energy projects (KPMG, 2021).

²⁵ This also applies to the nuclear power stations currently under construction or recently completed in countries including France, the United Kingdom and Finland.



One possible downside of market interventions favouring nuclear energy is that they have an impact on the possibility of using other instruments that could make the energy supply more flexible. If nuclear energy receives support or guarantees, investments in hydrogen production, for example, which do not have access to this support, may become less attractive to commercial operators.

Another possible way of making nuclear energy more cost-effective is to further adapt the current market model with the sustainability targets in mind. Several studies suggest that the current market model does not support an affordable energy transition (Schalij & Meijburg, 2020; Tieben et al., 2013). After all, the model gives priority to the lowest electricity price and does not provide, for example, for the payment of compensation to energy companies for savings made in terms of expanding the power grid, building reserve capacity or developing other types of stabilising system functions. In addition, social costs of CO₂ emissions are not fully reflected in energy prices. Regardless of whether nuclear energy should be part of the energy mix, the question is therefore how the current market model could be adapted to better support the realisation of a sustainable, affordable (and reliable) energy system.

Additional cost of targeting different energy sources

As we have already mentioned, targeting all possible sources of low-carbon electricity increases the robustness of the transition path. If one energy generation technology drops out during the transition, alternatives are available. Research shows that excluding options usually leads to higher

national costs. However, there are additional costs associated with oversizing the energy system. What price is a robust transition path worth to us as a society?

5.3 Safety and security

Safety and security is an essential prerequisite for using nuclear energy. Although the literature on nuclear energy offers many different definitions of safety and security, in practice it is a complex and emotive subject. All manner of ethical questions come into play here.

Gap between policy and society

In Section 4 we pointed out that there is a disconnect between the policy approach to nuclear safety, on the one hand, and the concerns about this issue that exist within large sections of society, on the other. Policy places the emphasis on the low probability of nuclear accidents, but people who are concerned about nuclear energy are afraid of the potentially major impact that a nuclear accident could have. This touches on fundamental ethical questions such as: how can we measure the different causes and consequences of a nuclear accident and weigh them up against each other? Some consequences are so far-reaching that even a low probability of them occurring can be problematic. An important task for the government, in our view, is to include other arguments and ethical reflection in the discussion about risks, in addition to numerical indicators.



Two other topics that frequently crop up in the debate on the safety and security of nuclear energy are: (1) the risks associated with the storage of nuclear waste and (2) the risk of illegal proliferation of nuclear materials and nuclear-related knowledge. The scientific knowledge on these two subjects is briefly discussed below.

Risks associated with storage of nuclear waste

According to experts, the risks posed by the temporary storage of nuclear waste at the Central Organisation for Radioactive Waste (COVRA) near Vlissingen are limited. This emerged during the expert meeting that we organised on 5 November 2021 on the safety and security of nuclear energy. In the event of an accident the expected consequences will mainly be local. The same applies to the consequences of a possible accident during the transport of nuclear waste.

There is less of a consensus among experts on the safety risks associated with the final disposal of nuclear waste. Some experts point out that research into safe final disposal of nuclear waste is now no longer so much about *whether* safe final disposal is possible, but mainly about *how* best to design final disposal from a technical perspective (OPERA, 2019). Other experts are critical, pointing to the very long half-life of high-level waste. Such waste contains components that will remain radiotoxic for tens of thousands of years.²⁶ These are time frames with which humanity obviously

²⁶ Reprocessed (vitrified) high-level nuclear waste has to be stored safely for around ten thousand years and spent fuel that has not been reprocessed for about a quarter of a million years (ANVS, 2016). After these periods the waste has the same radiotoxicity as the original uranium ore.

has no experience. This also raises the practical question of how future generations should be informed about these risks. The above raises two pressing ethical questions: (1) can we pass on responsibility for storing nuclear waste to the generations living in the next century? (2) in the event that something goes wrong during storage, is it legitimate to burden the people of the Netherlands with the radiotoxic consequences far into the future?²⁷

Risk of proliferation of nuclear material

The risk of the illegal proliferation of nuclear materials includes the risk of materials and/or knowledge being stolen and ending up in the hands of parties who want to make nuclear weapons. To prevent this, since 1970 the Netherlands has been a party to the so-called Non-Proliferation Treaty (NPT), officially known as the Treaty on the Non-Proliferation of Nuclear Weapons.²⁸

There is a high degree of consensus among experts that the risk of proliferation of nuclear materials and knowledge as a direct consequence of new nuclear power stations potentially being sited in the Netherlands is very small, but can never be completely ruled out. To minimise the risks, the Netherlands has decided that civil nuclear establishments (intended for research, education and the production of isotopes for medical applications)

²⁷ We discuss the final disposal of nuclear waste in more detail in Section 5 of Part 2 of the Dutch version of this advisory report.

²⁸ The NPT explicitly allows the use of nuclear energy for peaceful applications, including the enrichment of uranium. However, countries must apply the highest safety and security standards and safeguards and be fully transparent about all activities. This is the case in the Netherlands. Worldwide, nuclear energy is also subject to a system of national licensing aimed at ensuring safety and national and international supervision.



will only use low-enriched fuel, which cannot be used directly to make nuclear weapons. Numerous precautions have also been taken within the nuclear chain.²⁹ In contrast to many other countries, however, the Netherlands has chosen to ‘reprocess’ part of its radioactive waste (i.e. make it suitable for use in nuclear power stations again), which in theory entails a higher risk (Taebi & Kadak, 2010).

In addition, there is the risk of nuclear installations being sabotaged, resulting in nuclear accidents or radiological leakage and associated health risks. In our opinion, ethical reflection is needed on the question of how the very small risk of illegal proliferation of nuclear materials and knowledge and the risks of sabotage of nuclear installations should be weighed up.

More scientific knowledge needed on impact of nuclear accidents

As far as the safety of nuclear energy is concerned, we have found that there is currently insufficient scientific knowledge about two subjects:

1. Current scientific knowledge offers little insight into what the consequences of an accident involving a new, generation III(+) nuclear power station could be in the Netherlands. The legal limit values with which these new nuclear power stations must comply are a probability of 1 in a million per year or a probability of 1 in 100,000 per year that a person or a group of ten or more persons respectively will die as a result of a nuclear accident (ANVS, 2020). However, the available studies,

²⁹ For example to prevent the use of nuclear waste in the making of so-called dirty bombs. A dirty bomb is a weapon that derives its ability to kill and injure from ionising radiation, but without causing explosive nuclear reactions like a ‘real’ nuclear weapon.

including on the recently opened nuclear power station in Finland (STUK, 2019), are not directly applicable to the Dutch situation.

2. Most scientific studies³⁰ focus on the direct radiological consequences of a nuclear accident (the composition and quantity of radioactive substances and how they are released into the biosphere), without considering the social disruption and the ecological, economic, psychological and social problems that may be encountered in the aftermath of such an accident (see also: Hoge Gezondheidsraad, 2016). Even though there were no fatalities in the Fukushima nuclear accident, the incident had a profound impact on the lives of people forced to leave their original homes for good; these are also ethically significant consequences (Roeser, 2011).

In our opinion, to ensure a proper debate on nuclear energy, it is important to gain a greater insight into the two aspects of the impact of nuclear accidents that we have just mentioned. With regard to the risk of fatalities, we need knowledge that is tailored to generation III(+) nuclear power stations within the Dutch context. We also need knowledge specific to our country about accident and disaster management in the unpredictable and chaotic situations that almost always arise in the event of major accidents, in spite of existing rules and protocols. Following on from the research carried out by the Dutch Safety Board (OVV, 2018), the consequences of a possible nuclear accident in our neighbouring countries should also be made clear, as well as the form cooperation could take in the area of

³⁰ The National Institute for Public Health and the Environment (RIVM) discusses a number of studies on its website. See: <https://www.rivm.nl/straling-en-radioactiviteit/stralingsincidenten-en-kernongevallen/middelen-en-expertise/rekenen-en-modelleren>



disaster management. This should also include ethical reflection on which measures are appropriate and at what cost (RIVM, 2020). Within this context ethical considerations should be taken explicitly into account.

5.4 Sustainability

To determine whether a choice in favour of nuclear energy can be considered a ‘sustainable’ choice, various criteria have to be examined: the impact of nuclear energy on the reduction of CO₂ emissions, on the landscape, on resource consumption and on the environment (particularly regarding nuclear waste). We have summarised the scientific findings below.

Impact of nuclear energy on the rapid reduction of CO₂ emissions

When assessing the sustainability of energy generation, the ‘impact on climate change’ is a prominent criterion. There is broad scientific agreement on the climate impact of nuclear energy: it produces only limited CO₂ emissions, even if we consider the entire life cycle of a nuclear reactor. In terms of CO₂ emissions, nuclear energy is comparable to wind energy. Compared to solar energy, nuclear energy actually performs better (IPCC, 2014; UNECE, 2021).

One specific aspect of sustainability concerns the speed with which CO₂ emissions can be reduced. There is no scientific knowledge available on nuclear energy in this regard. It is not known whether a transition path with nuclear energy will reduce CO₂ emissions more quickly (or more slowly)

than a transition path without nuclear energy. This is a shortcoming in the debate, because the pace at which we bend the global CO₂ emissions curve makes a significant difference to the climate impact. Once emitted, CO₂ remains in the atmosphere for hundreds of years, unless special ‘negative emissions technologies’ are used. Large-scale, affordable technical solutions are being developed, but are not yet available.

Impact of nuclear energy on the landscape

Another sustainability-related aspect of energy generation technologies concerns the amount of space that installations take up; after all, this has an impact on the landscape. Energy generation involves *direct* and *indirect* land use. Direct physical land use relates to the ‘footprint’ of the installations in the environment: their surface area.

Indirect land use concerns (a) the spatial (safety) restrictions that apply around an installation, (b) the space required for connected components within the energy system (such as transmission lines and supply and processing chains), (c) the space required elsewhere in the country or the world to extract necessary raw materials and (d) the impact on people’s (aesthetic) experience of the landscape.³¹

³¹ The distinction between direct and indirect land use is made in various ways in the literature. The report by Berenschot and Kalavasta (2020), commissioned by Netbeheer Nederland, and the report by Kuijers et al. (2020), commissioned by the Ministry of Economic Affairs and Climate Policy, provide an insight in particular into direct, and sometimes indirect, land use. The report by Generation Energy, Bright and Groen Licht (2021), commissioned by the Ministry of the Interior and Kingdom Relations, focuses explicitly on indirect land use and also considers the necessary infrastructure, such as pipelines. The report *Ruimte in het klimaatakkoord* (Space in the Climate Agreement) (Hocks et al., 2018) details the land use for each sector. A comprehensive inventory is provided in the report *Klimaat Energie Ruimte* (Climate Energy Space) (Kuijers et al., 2018). Sijmons et al. (2017), CRa (2019) and CoP Windenergie en landschapskwaliteit (2021) also offer an insight, from a spatial perspective, into the choices that need to be made during the energy transition or parts of this process.



For nuclear power stations, direct physical land use is comparable to that of a gas-fired power station of equal capacity. However, the area taken up by nuclear power stations is significantly smaller than that of wind and solar power installations with a similar generation capacity.³² This is because hundreds of such installations are needed to achieve a generation capacity that rivals that of a 1,000 to 1,600 MW generation III(+) nuclear power station. By way of comparison, the existing Borssele nuclear power station has a capacity of 485 MW. Zeewolde wind farm, which is currently the largest onshore wind farm in the Netherlands, consists of 91 wind turbines with a combined capacity of 322 MW and covers an area of 300 square kilometres.³³

The indirect land use of nuclear energy is considerably greater than the direct land use, however, due to safety radii, temporary storage of nuclear waste and production and generation facilities for fuel rods. Space is also taken up in the event of a serious accident, if areas around a nuclear reactor have to be evacuated for a long period of time. The indirect land use of wind turbines consists of the facilities needed to connect a wind farm to the electricity grid and store (part of) the energy generated in batteries or

³² The direct land use of an individual wind turbine is very small. However, as they cannot be installed close to each other, a wind farm takes up a significant amount of space. This space between wind turbines can be given a multifunctional use, for example for agriculture, forestry or nature (CoP Windenergie en landschapskwaliteit, 2021).

³³ The wind farm consists of 91 new wind turbines, replacing the original 220 wind turbines that were installed here and there around the site twenty years ago. These new turbines have a combined capacity that is 2.5 times higher. The wind farm is a private initiative involving around 90% of local farmers, citizens and entrepreneurs, who have come together as shareholders in an energy cooperative. See also: <https://www.change.inc/energie/het-grootste-windmolenpark-op-land-van-nederland-opent-deze-zomer-38627>

(after conversion to hydrogen) in overground or underground reservoirs, although this also applies to nuclear energy if it is used to increase the flexibility of the energy system. People have differing perceptions of the way wind and solar farms are integrated into the landscape, but for some this aspect is an important argument against installing wind turbines and solar farms on a large scale.

The advantages and disadvantages of nuclear energy from a spatial perspective will have to be weighed up against each other (with consideration also given to how they are distributed across society). These advantages and disadvantages will then need to be compared with those of other energy sources. This will require not only quantitative comparative research, but also ethical reflection (see also 5.5). At the level of the energy system as a whole, it will be necessary to clarify the spatial impacts of choosing between a system without and a system with nuclear power stations.

Impact of nuclear energy on resource consumption

Energy generation goes hand in hand with the extraction of raw materials. From a sustainability perspective there are three important aspects here: (1) the environmental impact of extraction, (2) the extent to which the raw materials are finite and therefore exhaustible and (3) the possibility of reusing (recycling) the raw materials used.

Relatively few rare minerals and metals are needed to generate nuclear energy; only uranium is essential (JRC, 2021). In this respect nuclear energy



compares favourably with wind and solar energy. After all, to manufacture solar panels, wind turbines and the associated batteries, fuel cells and electrolysers, rare raw materials, such as lithium, cobalt, platinum and palladium, are needed. These technologies also make use of materials with limited availability, such as copper.

On the other hand, uranium (like other fissile materials) cannot be reused repeatedly and in its entirety for the same application, in contrast to lithium and cobalt, for example (even though these are not yet often reused in practice). For this reason (and also due to the radioactivity of certain components of a decommissioned nuclear power station) the recycling potential of nuclear energy is lower than that of modern wind turbines and solar panels (UNECE, 2021; Stamford & Azapagic, 2012).

It is estimated that there is sufficient uranium available to cover the energy transition period (GEA, 2012; OECD NEA & IAEA, 2020), but that a shortage of uranium may become a problem in the longer term (see also 5.5 below). However, the same argument also applies to other forms of energy generation: the availability of the rare metals (iridium) needed to produce hydrogen via electrolysis may also be a complicating factor in the long run (Wieclawska & Gavrilova, 2021; Metabolic et al., 2021).

It is clear that any energy system will be extremely reliant on specific minerals and metals. At the level of the energy system as a whole, it is necessary to clarify how the design of the energy mix affects the demand for raw materials. Consideration must be given to the level of resource consumption that is acceptable.

Ethical aspects also come into the equation here. The question of fairness towards non-industrialised countries where raw materials are extracted plays a role, for example. When it comes to the extraction of raw materials, environmental pollution, working conditions and unequal wealth distribution are all relevant issues.

Generally speaking, lowering the demand for energy is important in order to reduce the demand for raw materials. However, this requires people to adapt their behaviour and may have an impact on their prosperity and comfort. That means there is an ethical consideration involved here too.

Impact of nuclear energy on the environment: disposal of high-level nuclear waste

From a sustainability perspective, the uncertainty that has existed to date about possible ways of ensuring the safe and permanent final disposal of high-level nuclear waste can be regarded as a disadvantage of nuclear energy compared to other forms of energy generation. Dutch policy states that a final decision on the method to be used for final disposal must be taken by 2100 and that final disposal must be available by 2130.³⁴ However, European Directive 2011/70/Euratom requires the Netherlands to take steps now with a view to achieving safe and responsible final disposal. The Dutch government has therefore commissioned COVRA to carry out a study looking into this issue. This Research Programme on Final Disposal of Radioactive Waste (OPERA), which ran from 2011 to 2018, focused on 'deep

³⁴ According to the government, this policy choice is legitimate, given the availability of a good temporary storage facility for high-level waste with sufficient space to dispose of the waste from the Borssele nuclear power station.



geological final disposal' in clay or rock-salt deposits. The assumption is that the physical properties of these soil layers will prevent any further spread of radioactivity. There is no certainty about this, however. The main risk involved here is the possible radioactive contamination of (ground)water and the habitat of organisms, both underground and on the surface.

In the first OPERA study, despite highlighting some uncertainties, the researchers express their confidence in the technical feasibility of final disposal of high-level nuclear waste in clay, although they indicate that there are also ethical considerations that should be explicitly taken into account, a process in which citizens should also be involved (Verhoef et al., 2017).³⁵

However, the methods and mathematical models used in the OPERA study have been criticised (Löhnberg, 2020). This criticism relates to aspects such as the handling of uncertainties outlined by OPERA itself, as a result of which it is claimed that safety has not been demonstrated beyond doubt. The OPERA Advisory Group (Adviesgroep OPERA) (2018) has indicated that in addition to gathering scientific knowledge, public participation is needed for decisions to be made about the final disposal of high-level waste. At the request of the State Secretary for Infrastructure and Water Management, in 2024 the Rathenau Instituut will issue an advisory report on the organisation of the decision-making process relating to long-term radioactive waste management.³⁶

³⁵ A second OPERA study on the disposal of nuclear waste in salt deposits will follow at a later stage.

³⁶ The progress of this research programme can be followed on the Rathenau Instituut's website: <https://www.rathenau.nl/nl/dossier-advies-besluitvormingsproces-toekomst-radioactief-afval>

At the moment we note that there are still many uncertainties regarding the permeability of soil layers. If the option of nuclear energy is to be explored further, more research should be carried out in this area (see also Section 5 of Part 2 of the Dutch version of this advisory report).

5.5 Distributive justice

If the Netherlands were to opt for one or more new nuclear power stations, it would have to investigate how the benefits and burdens associated with this choice would be distributed between areas of the Netherlands, between the Netherlands and other countries and between our generation and the generations that will follow us, as well as whether this distribution would be just and acceptable. Issues that we have already discussed above will therefore be touched on again in this section, but this time from the perspective of justice. These include: in which regions will nuclear power stations be located, where will nuclear waste be stored, how much of the finite raw material uranium will we leave for future generations, under what conditions is the production of nuclear waste justified and how can this waste be stored, given the burden this could create in the future?³⁷

Selection of sites for nuclear power stations

In the Netherlands there are three designated sites where the possible construction of a nuclear power station may not be obstructed: Borssele,

³⁷ There are also financial burdens that will need to be shared, of course. Here we are talking about questions such as: which portion of the costs of an energy system that includes nuclear energy will be borne by the energy companies and which portion by the government? This aspect will not be considered here.



Maasvlakte I and Eemshaven. These are referred to as ‘reserved sites’.³⁸ The choice of a site for a nuclear power station does not have to be limited to the reserved sites. A permit application may also be submitted for another location, provided that it meets the conditions and requirements laid down in the Third Electricity Supply Structure Plan³⁹ and physical environment policy.

Selection of sites for final disposal of high-level nuclear waste

The location of a permanent final repository for high-level nuclear waste is linked to specific properties of the subsurface. Rock-salt or clay deposits are currently being considered (see 5.4).

In the north-east of the Netherlands, where there are salt deposits in the deep subsoil, the possibility of final disposal has caused unrest among the local population at various times in recent decades, leading to a temporary halt to further research. The question is under what conditions will the establishment of a final repository be acceptable to local residents. An alternative option touched on in the debate is to undertake final disposal in cooperation with other countries. With this in mind, in January 2021 the European Repository Development Organisation was established, within which European countries with relatively small amounts of radioactive waste are exploring the possibility of joint final disposal (ERDO, 2021).

³⁸ In two motions the House of Representatives has asked the government to remove Eemshaven from the list of reserved sites, partly in view of the burdens that the province of Groningen is already experiencing as a result of natural gas extraction on its territory (Tweede Kamer, 2021a; 2021b). The government has not yet acted on these motions.

³⁹ The Third Electricity Supply Structure Plan (SEV III) stipulates where in the Netherlands new power stations with a capacity of 500 MW or more may be located. The SEV III will be replaced in the future by the Main Energy Structure Programme.

Another possibility is to purchase space at the Finnish final repository. For the time being, however, this is only a theoretical possibility, as current Finnish legislation states that this final repository may only be made available to nuclear waste from Finland.

Extraction of finite raw material uranium

Naturally available uranium reserves are expected to be more than sufficient to cover the period of the transition to a climate-neutral energy system. There are also opportunities to reduce uranium consumption⁴⁰ and in the future it may be possible to extract uranium from seawater.⁴¹ However, as with many other raw materials, at current levels of consumption and at current prices the uranium reserves known to be present in the ground could run out in a hundred to a few hundred years if recycling does not improve (OECD-NEA & IAEA, 2020). In such a case, a shortage of uranium could become a problem in the long term.

It is conceivable that future generations, possibly long after us, will need the specific properties of uranium as a raw material with very high energy density. If we accept that present generations have moral responsibilities towards future generations, no matter how distant, this raises the question of the conditions under which uranium consumption is justified (Gardiner, 2003; Taebi, 2021). This does not preclude the ethical use of nuclear energy

⁴⁰ In addition, thorium ore is a possible future source of uranium for use in certain types of reactors.

⁴¹ Seawater contains a lot of uranium, which, given its very low concentrations and the environmental impact, cannot be extracted using current technologies and at current cost levels, but it may be possible to extract it in the future. According to estimates, very large quantities of uranium could potentially be extracted from seawater.



(Taebi, 2021), but it does require us to think about compensation for future generations, the precise use of uranium and the management of potentially reusable waste (Barry, 1989).

Nuclear waste now and in the future

As part of the scientific debate it is pointed out that the issue of nuclear waste also entails ethical obligations towards future generations (Kermisch, 2016). A widely accepted moral principle is that nuclear waste should not impose an 'undue burden' on specific groups, countries or future generations (Fattah, 1995). However, it is difficult to determine under what conditions nuclear waste does not constitute an 'undue burden'. Indeed, the final disposal of nuclear waste involves fundamental technical and ethical uncertainties that can never be completely eliminated. There is consensus among member states of the Organisation for Economic Co-operation and Development (OECD) that the deep underground storage of nuclear waste in purpose-built repositories – or geological disposal – is the best way to give effect to the principle of avoiding undue burdens in the future (NEA-OECD 1995; IAEA 1997).

The ethical question here is whether and under what conditions the production of nuclear waste can be considered just. This difficult question will also have to be considered as part of the political decision-making process relating to nuclear waste. A crucial sub-question here will be: if we want to respect the right of future generations to make different choices, what form of waste disposal is responsible?

Within this context we may consider whether and how nuclear waste placed in a geological disposal facility should be retrievable. Permanently sealing the repository may be a safer and also cheaper option, but it makes it difficult to (a) make adjustments in the event of problems or (b) reduce the radiation risks when new disposal technology becomes available. A second argument in favour of retrievable disposal may be that useful residual material that could be used in future reactor types remains accessible, for example. Another sub-question to be answered will be whether and how final disposal sites should remain identifiable for future generations. If they should remain identifiable, this raises the question of what kind of (visual) language would be best to use and whether institutions should be established to take care of this communication (OECD & NEA, 2015).





6 ANSWERS NEEDED TO ENSURE A FUTURE-PROOF DECISION

In the previous section we examined, from various perspectives, the possible role that nuclear energy could play within a carbon-neutral energy system. Our analysis reveals that various questions remain outstanding. These questions need to be answered to reach an informed decision on the possible future role of nuclear energy in the Netherlands. In the first instance, there are questions relating to missing information that is important for the decision-making process; this knowledge will need to be acquired. Secondly, there are policy-related questions, which will require political and social consideration; see also Figure 4.

Figure 4: Policy questions and knowledge questions surrounding nuclear energy derived from reflection on values



6.1 Knowledge to be acquired

A great deal of knowledge is available about nuclear energy, but there are also a number of uncertainties. It is important to identify these uncertainties so that the necessary knowledge can be acquired in a targeted way. This is not to suggest that acquiring knowledge can remove all uncertainties. Any uncertainties that remain should be recognised as such to allow them to be taken into account in the decision-making. More knowledge is needed on at least four issues, which we discuss below.

1. *What is the cost difference between an energy system with and an energy system without nuclear energy?*

Several recent studies suggest that the cost of an energy system with nuclear energy may be lower than the cost of one without. Some studies paint a different picture, however. The uncertainty in the calculations and the differences in the assumptions employed are so great that definitive statements cannot yet be made. Even small adjustments to the assumptions quickly lead to differences in price. Further scientific assessment of the assumptions is therefore needed. Ongoing monitoring is important here to allow new developments to be incorporated into the assumptions.

The lack of knowledge about the costs of an energy system with or without nuclear energy is an obstacle in the debate. At the moment, in view of the results of the studies carried out in this area, we think it makes sense for the government to work from the assumption, when preparing policy, that the national costs of the energy transition with and without nuclear energy are more or less comparable.

2. *What energy system contributes most to acceleration of the energy transition?*

It is clear that nuclear energy can contribute to the transition to a carbon-neutral energy system. But how great a contribution can it make, compared to that of clean, renewable forms of energy generation such as wind and solar power?

There is currently no consensus about whether adding nuclear energy to a clean energy mix would accelerate or delay the transition path. Some believe that using nuclear energy could accelerate the achievement of energy transition targets, because it reduces the pressure on other options, is easier to integrate into the high-voltage grid and requires construction techniques that differ from those for which a huge increase in capacity is currently needed. Others point out that nuclear energy could cause delays, because (a) both policymakers and the business community would have to divide their attention between various options, (b) nuclear energy gives rise to public debate and resistance, (c) a considerable amount of time would be needed to rebuild the necessary production and innovation capacity in the Netherlands and (d) nuclear power stations take a long time to complete. Precisely because the global CO₂ emission standard that we have to meet to limit global warming to a maximum of 1.5°C is at risk of being exceeded in the short term (beginning of 2030), greater insight is needed into the best way to accelerate the transition path. Clarity is also needed about other government interventions that could help to accelerate the energy transition.



3. What would the direct and indirect consequences be of a possible nuclear accident in the Netherlands, and is the Netherlands sufficiently prepared?

At present, we do not have a complete picture of the direct and indirect consequences that an accident involving a generation III(+) nuclear power station would have in the Netherlands. Direct consequences of radiation have not yet been calculated. Indirect consequences, such as social disruption and the social and psychological consequences of disaster management (which sometimes have a greater impact than the direct consequences), are not yet well understood. It is important to conduct targeted research in this area. The international aspects of a nuclear accident and longer-term direct and indirect consequences should also be considered as part of this. On the basis of this knowledge, it will be possible to determine which measures are needed to ensure our country is as well prepared as possible for the consequences of a nuclear accident, how these can be minimised and whether we consider the remaining risks and uncertainties to be ethically acceptable.

4. What technological and financial uncertainties are associated with the final disposal of high-level waste?

From a policy perspective, different options are being explored for the final disposal of high-level nuclear waste in deep geological strata: disposal within the Netherlands (through storage in repositories, which may or may not be permanently sealed, in clay or rock-salt deposits) and international disposal (through the purchase of storage space in another country's final repository). At present, there is no certainty as to what is the best solution,

financially and technologically speaking. As high-level nuclear waste emits radiation over tens of thousands of years, inherent uncertainties will remain. The lack of knowledge is due in part to the low priority the Netherlands has attached to final disposal to date; a decision on this issue is planned in 2100.

6.2 Aspects still to be considered

Our analysis reveals seven policy-related questions that need to be answered if an informed decision is to be made about the possible role of new nuclear power stations within the Netherlands' future energy system.

1. How do we intend to deal with peaks and troughs in the supply of solar and wind energy?

A reliable carbon-neutral energy system is achievable both with and without nuclear energy. In the case of an energy system in which sunlight and wind are the main sources used for power generation, it is crucial that generation capacity is also available to cover times when the sun is not shining and the wind is not blowing. This can be achieved through a combination of (in no particular order): (a) energy generation that can be scaled up or down at any time, such as generation based on nuclear energy, natural gas or biogas, (b) storage of electricity in energy carriers such as batteries, hydrogen and heat, (c) conversion of electricity into heat, hydrogen and other compounds (such as ammonia or methane) (d) construction of cross-border electricity interconnectors for imports from and exports to other countries and (e)



management of the demand for energy. Within this question there are three further sub-questions:

- To what extent is the ruling out of certain options ethically and socially acceptable? Excluding nuclear energy increases the dependence on the combined use of other options.
- To what extent are the consequences of incorporating diverse energy generation technologies into the flexible energy mix ethically and socially acceptable? After all, every technology also has disadvantages, for example in terms of the space taken up, the impact on the landscape, safety, costs, resource consumption and geopolitical dependence.⁴² How do systems with and without nuclear energy differ in terms of these disadvantages?
- To what extent is reducing demand for energy necessary from an ethical point of view? A lower level of energy consumption has many advantages when it comes to organising the energy system and reducing CO₂ emissions, but it also requires changes in behaviour and can have an impact on prosperity and comfort. A reduction in demand can be achieved in part by developing more energy-efficient technologies, but also by focusing on more radical societal choices through investments in sustainable solutions, for example in the areas of transport and manufacturing.

⁴² This last aspect, dependence on other countries linked to the use of specific energy carriers, such as natural gas or uranium from Russia, has not been examined separately in our analysis. It is, however, a relevant and important factor to consider when it comes to the composition of the desired energy mix.

2. How robustly do we want to organise the energy transition and at what cost?

Targeting a broad mix of energy generation technologies and a good balance between a centralised and a decentralised energy system will lead to greater robustness along the energy transition path. Nuclear energy therefore has an option value, which can be exploited in three ways: (1) keeping the option of nuclear energy open, so that there is a fallback option if an approach without nuclear energy proves to be unworkable; (2) committing to nuclear energy straight away, so that our chances are spread and there is less dependence on (the success of) specific technologies; (3) adding nuclear energy to an already robust transition path, so that there is room to deal with setbacks (for example in the commissioning of offshore wind farms or the roll-out of hydrogen production) and a wider set of choices remains available in the longer term. All options involve costs and revenues, and the question is how these will be distributed among electricity consumers and taxpayers.

What costs are we prepared to accept to ensure a robust transition path, where investment in developing sufficient knowledge is a necessary condition for keeping additional options available? Oversizing energy generation technologies therefore comes at an additional cost. On the other hand, model-based calculations show that excluding specific energy generation options also leads to higher national costs (Scheepers et al., 2020).



3. What safety and security risks of an energy system with or without nuclear energy do we consider acceptable and how will we determine these risks?

Before any decision is made on nuclear energy, the risks of a nuclear accident, the risks of nuclear waste disposal and the risks of illegal proliferation of radioactive materials must be carefully considered and weighed up against the risks of an energy system without nuclear energy (for example, a system that includes large-scale underground storage of hydrogen or CO₂). Relevant sub-questions relating specifically to nuclear energy are:

- When it comes to controlling risks, do we focus mainly on minimising the probability of an accident or also on minimising the possible consequences of an accident?
- How does the government ensure that it genuinely fulfils its responsibility (a) to assess, monitor and guarantee the safety of new nuclear power stations and (b) to act in the event of a serious accident?
- How prepared is society, including in Germany and Belgium, for a possible nuclear disaster or for dangerous situations involving the disposal of nuclear waste and the illegal proliferation of radioactive material? And do we consider the investments needed for such preparation acceptable and worthwhile?

4. How much importance do we attach to the impact that a choice in favour of nuclear energy will have on the landscape?

In the Netherlands' future energy system wind and solar farms will account for a large share of electricity generation. However, if nuclear energy also

plays a role within the energy system, the need for onshore wind and solar farms may be smaller, meaning that – provided there is an appropriate spatial-planning policy in place – wind turbines and solar farms will have less of an impact on the landscape. It will be necessary to clarify what the spatial consequences will be of integrating one or more nuclear power stations into the energy system and which options, including the distribution of the resulting impacts, are the most desirable ethically and socially.

5. How much importance do we attach to the impact of using finite resources when deciding in favour of or against including nuclear energy in the energy system?

Nuclear energy, wind turbines and solar panels (and the associated batteries and electrolyzers) all depend on finite resources that have to be sourced from abroad. Solar and wind power require more of such critical resources than nuclear energy. On the other hand, modern wind turbines, solar panels and batteries are largely recyclable. Nuclear energy requires other raw materials, such as concrete and steel, as well as the nuclear fuel uranium. Although, in principle, large quantities of it are naturally available, uranium is a finite resource. The impact that the extraction of the finite resources required for certain technologies has on quality of life on our planet, including for future generations, will have to be taken into account when making decisions.



6. What do we think is a just distribution of the benefits and burdens associated with a potential choice to include nuclear energy in the energy system?

Decisions that are beneficial at the level of the energy system can sometimes have disproportionate disadvantages for specific groups or specific locations. Here we are talking about how costs are distributed, where energy is generated and waste is processed and stored, and who is exposed to landscape-related impacts and risks. The same applies to the impacts of mining abroad. The question to be answered here is: what distribution of burdens between groups and areas do we consider acceptable and under what conditions? What are the issues linked to the distribution of burdens that apply to nuclear energy, compared to other energy sources that rely on critical, rare or finite materials?

7. With which consequences of our choices relating to a carbon-neutral energy system and the possible role of nuclear energy within it is it acceptable to burden future generations?

If we choose to build new nuclear power stations in order to achieve a carbon-neutral energy system, we will burden future generations with three problems. Firstly, we will be making generations in the near future responsible for the permanent disposal of nuclear waste. Under current policy, the generation that is alive in around 2100 (when the nuclear power stations currently under consideration have reached the ends of their lifespans) will have to decide on a definitive solution to deal with the nuclear waste. Secondly, we will be making several generations after them

responsible for operation of the final repository. Thirdly, future generations may have less uranium at their disposal.

The extent to which it is ethically acceptable to pass these problems on to future generations will have to be weighed up when decisions are made about the possible construction of additional nuclear power stations. Important questions to be addressed here are: how great a burden will nuclear waste place on future generations and how can this burden be alleviated? What risks can and cannot be passed on? We can also ask ourselves whether it is ethical not to do everything possible to prevent global warming. The consideration of these questions may not only influence the decision in favour of or against constructing new nuclear power stations, but could also prompt us to adjust the current policy of not deciding on the final disposal of nuclear waste until 2100, for example.





7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Our analysis of the debate within society and in political and scientific circles on the possible role of nuclear energy in the Netherlands leads us to four conclusions. They concern the essential preconditions that must be met to ensure decisions on this issue are made diligently.

1. **Decision-making on nuclear energy requires not only technical knowledge, but also ethical consideration and reflection.**

Decision-making on nuclear energy is not only a technological issue, but also touches on important ethical values. Nuclear energy is therefore a subject that, like the energy transition as a whole, continues to provoke discussion and arouse emotions. That is because the values associated with it are of concern to citizens. Technical knowledge and optimised calculation models can help enormously in making diligent and well-founded decisions on this matter, but this kind of quantitative information alone is not enough. Ethical consideration and reflection are also needed.

2. Involving citizens is an essential prerequisite for ensuring diligent decision-making on nuclear energy.

To ensure future-proof decision-making on the possible construction of new nuclear power stations, it is essential that procedures are made transparent to citizens throughout the process and that their views are explicitly included when decisions are made. This is all the more important given the long time it takes to complete such processes.

The decision-making process and – in the event of a positive decision – the actual construction of new nuclear power stations is expected to take several government terms. Citizens will need to be seriously involved at every stage. For the current government's term of office, this means that the government will need to be transparent about the preparatory steps it intends to take by assisting commercial operators in their exploration of options for investment.

Involving citizens seriously means that civic engagement should not simply be organised with the aim of creating support for an outcome desired by the government. The decision-making process should be truly 'open'. This means that the outcomes are not determined in advance, that there is scope for new insights to be introduced and that it is possible for an original proposal to be revised following social and ethical reflection (see Recommendation 5 for specific details relating to this point).

3. Decision-making on nuclear energy should be explicitly linked to values.

During the decision-making process on the future role of nuclear energy in the Netherlands, it is important to state explicitly how the five values that we have identified, and that are widely recognised as relevant reference

points for the debate about our future energy system, will be dealt with: energy supply certainty, affordability, safety and security, sustainability and justice (procedural as well as distributive).

Linking decision-making to these five values will not necessarily lead to consensus, but it will promote a high-quality debate in which the considerations of others will be more easily understood. Part of this process involves recognising that values cannot always be judged objectively: what is just (or sustainable) for one person may not be so for another, for example. This is a necessary ingredient for achieving diligent, broad-based decision-making.

4. The influence of nuclear energy on the pace of the energy transition is a factor to be considered in the decision-making.

When considering the possible addition of nuclear energy to the Dutch energy system, it is important to consider carefully how this would affect the speed of the 'transition path'. As far as this transition path is concerned, the motto is: the faster the better. After all, the pace at which the global CO₂ emissions curve is bent makes a significant difference to the climate impact.

7.2 Recommendations

The above considerations lead us to five recommendations on the possible use of nuclear energy within the Dutch energy system.



1. Make policy choices about the energy system as a whole rather than individual parts of it.

In this advisory report we have focused on the role of nuclear energy. During the advisory process, however, we concluded that policy choices about nuclear energy cannot be made in isolation. To make such choices, a comprehensive assessment is therefore needed of the energy system as a whole.

2. Enhance factual knowledge about the energy transition and the possible role of nuclear energy within it and entrust this task to the yet to be established climate council.

The provision of information about the energy transition and the possible role of nuclear energy within it needs to be enhanced, as there are still many aspects that are uncertain or unclear. We have identified four issues about which additional knowledge is required to allow the role of nuclear energy within the energy system to be properly weighed up against other energy sources:

- What is the cost difference between an energy system with and an energy system without nuclear energy? In the absence of any consensus on this point, we think it makes sense for the government to work from the assumption, when preparing policy, that the national costs of the energy transition with and without nuclear energy are more or less comparable.
- What energy system contributes most to acceleration of the energy transition?

- What would the direct and indirect consequences be of a possible nuclear accident in the Netherlands, and is the Netherlands sufficiently prepared?
- What technological and financial uncertainties are associated with the final disposal of high-level waste?

It is important that quantitative studies and reports on the above issues (the optimal energy mix, the safety and security risks and the uncertainties surrounding permanent disposal of nuclear waste) can be assessed in terms of their underlying assumptions and how they handle uncertainties. We believe that the climate council to be established under the terms of the coalition agreement has a valuable role to play here. In our opinion, this climate council should fulfil the role of a scientific intermediary with regard to knowledge about the energy transition and climate. We believe it is important that the climate council also includes experts in the fields of ethics, psychology and sociology, spatial sciences and economics.

3. When deciding on the organisation of the future energy system and the possibility of incorporating nuclear energy into it, assess explicitly at least seven key questions identified in this advisory report.

The government is working on the *National Energy System Plan for 2050*. This will include decisions on the organisation of the future energy system and the possibility of incorporating nuclear energy into it. Our analysis highlights seven questions that will need to be considered carefully before final policy choices are made about the energy system of the future:



- How do we intend to deal with peaks and troughs in the supply of wind and solar energy?
- How robustly do we want to organise the energy transition and at what cost?
- What risks of an energy system with or without nuclear energy do we consider acceptable and how will we determine these risks?
- How much importance do we attach to the impact that a choice between different energy generation options will have on the landscape?
- How much importance do we attach to the impact of using finite resources when deciding in favour of or against including particular forms of energy generation in the energy system?
- What do we think is a just distribution of the burdens of the energy system?
- With what consequences of the energy system is it acceptable to burden future generations?

4. When making choices about the possible inclusion of nuclear energy in the energy system of the future, clarify how the five values have been interpreted and what trade-offs have been made.

The five values arising from our analysis can serve as a useful guide for clarifying trade-offs relating to the organisation of the future energy system and the possible role of nuclear energy within it. Our analysis reveals that these values (energy supply certainty, affordability, safety and security, sustainability and justice) can be interpreted in different ways and can also be prioritised differently relative to each other. When choices are being made about nuclear energy, we call on the government to clarify how

it interprets the five values and what technical and ethical trade-offs are involved. The uncertainties in the decision-making process should also be explicitly addressed. Maximum transparency promotes open discussion about the choices to be made and will enhance the quality and justness of decision-making, which may also help to increase acceptance of decisions made.

5. Involve citizens explicitly in weighing up values during the debate on the organisation of the energy system and the possible role of nuclear energy therein.

Over the coming years we expect there to be public debate about the organisation of the energy transition at various times – especially when it comes to the possible construction of new nuclear power stations. Part of this debate will be conducted in the usual way and be based around: (a) stakeholder input before a decision is made on the location of a potential new nuclear power station and (b) input from the House of Representatives before the financing of potential new nuclear power stations is approved by Parliament.

We believe that, in addition, the government and Parliament should explicitly involve citizens in weighing the relevant values (energy supply certainty, affordability, safety and security, sustainability and justice). At the moment, these values are not being sufficiently considered in the discussion about the national energy system of the future. It is important that during the debate proper consideration is given to the different perspectives from which the issue can be viewed. This civic engagement



will contribute to the quality, diligence and justice of decisions. This way, decisions will be more societally embedded.

The Council supports the proposal made by the Minister for Climate and Energy Policy, also on behalf of the Minister of the Interior and Kingdom Relations (EZK, 2022c), that the government, together with the House of Representatives, should look into the possibility of establishing a citizens' assembly on the development of our future energy system. We believe that in principle a *citizens' assembly* is an adequate form of citizen participation to advise the government and the House of Representatives about the future energy system and the possible role of nuclear energy therein. The knowledge gaps referred to under Recommendation 2 need to be filled in advance, however.



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Nature-inclusive Netherlands: nature everywhere and for everyone.
[‘Natuurinclusief Nederland: natuur overal en voor iedereen’]. March 2022
(Rli 2022/01)

2021

Farmers with a future. [‘Boeren met toekomst’]. December 2021
(Rli 2021/06)

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(Rli 2021/05)

National Growth Fund. [‘Investeren in duurzame groei’]. October 2021
(Rli 2021/04)



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