Environmental Impact Assessment

Amendment of the Nuclear Energy Act
Ministry of Economic Affairs and Climate Policy

14 June 2024 - Public

Contents

1 Introduction

1.1 Background

In its Coalition Agreement in 2021, the fourth Rutte cabinet announced that it wanted to keep the Borssele nuclear power plant in operation beyond 2033. The first step in facilitating that is amending the Nuclear Energy Act. Currently, Section 15a of the Nuclear Energy Act states that the Borssele nuclear power plant may not release any nuclear energy after 31 December 2033. It also states that any application for a permit extension will not be considered. The intention is to amend Section 15a of the Nuclear Energy Act so that an application for a permit extension can be considered.

Once the Nuclear Energy Act has been amended, the second step in the process will consist of a permit application to the Authority for Nuclear Safety and Radiation Protection (ANVS) by the operator of the nuclear power plant. The operator of the nuclear power plant will have to demonstrate that the plant can continue to comply with all the relevant requirements which apply in the Netherlands in the long term, including the international standards.

This Environmental Impact Assessment Phase 1 is focused solely on changing the Nuclear Energy Act and sets out the main environmental impacts of the existing operation of the nuclear power plant. The Environmental Impact Assessment also contains an extrapolation of environmental impacts (where possible) and an agenda listing environmental focal points, which are relevant to the next phase of the licensing process (Phase 2). Once all of this has been taken into account, decisions can be taken regarding a potential legislative amendment. These decisions, along with the results of yet to be performed technical studies, the environmental impacts of keeping the plant operational for an extended period of time and the required permits, would make up Phase 2. The decision as to whether the nuclear power plant does in fact remain operational for longer will not be based on this Environmental Impact Assessment Phase 1.

1.2 Scope of this Environmental Impact Assessment Phase 1

This section discusses the scope of the Environmental Impact Assessment (EIA) Phase 1. What is EIA Phase 1 about? And, just as importantly, what is it not about?

1.2.1 Intention to amend the Nuclear Energy Act

This Environmental Impact Assessment Phase 1 is part of the proposal to amend the Nuclear Energy Act. The result of the proposed amendment will solely be to eliminate the legal obstacle to the Authority for Nuclear Safety and Radiation Protection (ANVS) considering a potential permit application from EPZ for the extension of operations of the Borssele nuclear power plant. It is therefore solely about enabling the operator of the Borssele nuclear power plant to submit an acceptable permit application. At this stage (EIA Phase 1), the issue of consent for a potential further operating life extension is not being considered.[1] Other decisions regarding the operating life extension would then be made at a later stage and be substantiated in Phase 2.

1.2.2 Existing public law rights of the Borssele nuclear power plant

In its response to the draft Memorandum on Scope and Level of Detail, the EIA Committee raises the question (in Section 4.4) as to what extent public law rights will still exist after 2033 under Section 15a of the Nuclear Energy Act. According to the EIA Committee, this is relevant to the agenda listing environmental focal points outlined in this EIA. The Ministry of Economic Affairs and Climate Policy (EZK) emphasises that this question (the extent to which public law rights will still exist after 2033) cannot remain unanswered and that clarity must be established for the future in this regard. However, at this stage of the EIA procedure (Phase 1), answering this question is not yet relevant.

[1] This EIA makes reference to an operating life extension rather than a lifetime extension. However, in EIA Phase 1, both terms are used to mean the same thing: the prolongation of operations of the Borssele nuclear power plant to release nuclear energy after 2033.

For it to become so, the actual decision to apply for a permit for the operating life extension must first have been taken by the operator of the Borssele nuclear power plant. This decision is not part of EIA Phase 1 and is partly dependent on the result of the technical studies currently being carried out.

Secondly, the answer to the question regarding existing public law rights is not essential to the objectives of this EIA Phase 1, since it is concerned with mapping out the environmental impacts of the existing situation, extrapolating them beyond 2033 where possible and drawing up an agenda listing environmental focal points that require attention in Phase 2. The environmental impacts will be mapped out as they are and are not dependent on any existing public law rights.

Thirdly, it is currently not possible to answer this question because the answer is dependent on the precise manner in which the operation of the power plant is to be prolonged (among other factors). This is as yet unclear. As soon as it becomes clear, as part of EIA Phase 2, an assessment will be made as to which permits will potentially be required – based on the environmental impacts identified. An assessment will then be made as to *whether* existing public law rights apply and, if so, *which* existing public law rights apply and what their consequences are for the permit application procedure.

1.2.3 the energy mix

Section 15a of the Nuclear Energy Act stipulates that the permit granted for maintaining the Borssele nuclear power plant in operation expires on 31 December 2033, as regards the release of nuclear energy. Section 15a(2) of the Act provides that no application will be considered for a licence for the release of nuclear energy by the plant after 31 December 2033. In order to enable the prolongation of operations as regards the release of nuclear energy beyond 31 December 2033, Section 15a of the Nuclear Energy Act needs to be amended. This legislative amendment is the necessary first step towards removing an obstacle to keeping open the possibility of an operating life extension beyond 2033.

There are four possible consequences of the legislative amendment:

- No permit application is submitted, for example because technical studies reveal that keeping the Borssele nuclear power plant operational for longer is not economically or safely achievable.
- A permit application is excluded from consideration, for example because it does not meet the statutory requirements.
- A permit application is considered but no permit is granted,because there are unacceptable or impermissible consequences. There is an imbalance in the allocation of functions between different areas.
- A permit application is considered and a permit is granted.

If the statutory barrier is removed, an application for a permit (the whole of all the required permits and procedures) may be submitted and considered.

The Netherlands' climate objective for 2050 is to be climate-neutral; for 2035, the objective is that no CO_2 should be released in the production of electricity[2]. The National Energy System Plan (NPE) issued in December 2023 sets out a vision of the composition of the energy mix in the year 2050. In that plan, nuclear energy makes up an intrinsic part of the energy mix: the plan allows for the possibility of an operating life extension for the Borssele nuclear power plant and the construction of two new nuclear power plants. Alongside the NPE, the National Energy Network Programme (PEH) describes the required future energy infrastructure in more detail. Section 2.2 further explains the role of nuclear energy in the energy mix.

This procedure does not address the question '*why include nuclear energy in the energy mix?*'. There are other procedures which consider the Netherlands' energy system more widely. In those procedures, multiple questions/sub-questions regarding the role of nuclear energy (its value and necessity, nuclear energy as part of the mix, dealing with radioactive waste, the relationship with nearby projects, the potential construction of new nuclear power plants) are answered. The related procedures are explained further in Section 2.3.

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[2] Climate Memorandum 2022, Ministry of Economic Affairs and Climate Policy (November 2022).

1.3 EIA requirement, procedure and participation

1.3.1 EIA requirement

The Environmental Impact Assessment (EIA) is an aid to decision-making. The purpose of the EIA is to give full weight to the environmental aspect in reaching a decision on a plan or project. An important element of the EIA is objectively describing the relevant environmental impacts of a plan or project in an Environmental Impact Assessment report. The EIA instrument provides a structure for information relevant to decision-making and also plays an important role in creating transparency and in participation. Under national law, a legislative amendment does not *in itself* directly result in an EIA requirement. However, at the European level there are legal grounds for completing an EIA procedure. These are discussed in more detail in the next section.

1.3.2 The EIA procedure in relation to overarching legislation

When preparing this legislative proposal, it was decided to perform an Environmental Impact Assessment. This choice was made in response to various elements of the overarching legislation which also provide grounds for completing an EIA procedure. The following relevant elements of this overarching legislation are considered in more detail in this section:

- The Espoo Convention (Convention on Environmental Impact Assessment in a Transboundary Context);
- Communication of the European Commission;
- The Aarhus Convention (Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters);
- The European ruling on the Doel nuclear power plant.

1.3.2.1 The Espoo Convention

Content of the Espoo Convention

The Espoo Convention (*Convention on Environmental Impact Assessment in a Transboundary Context*) imposes a duty on parties to institute an environmental impact assessment procedure that provides for public participation for proposed activities with a potentially significant adverse transboundary impact[3]. This may relate to a new activity or a substantive alteration to an existing activity. The existence of such a new or altered activity, combined with potentially significant adverse transboundary environmental impacts, mean that under Section 2(3) of the Espoo Convention, an EIA must be drawn up to map out those transboundary impacts. Special guidelines have been drawn up to ascertain the applicability of the convention to operating life extensions of nuclear power plants[4]. These guidelines address the question as to in which situations an operating life extension may be possible. One of those situations is when a nuclear power plant has a permit for an indefinite period but the operating life of the nuclear power plant is limited by law[5]. This applies to the situation of the Borssele nuclear power plant. In this case, the permit has been granted for an indefinite period but the operating life is limited by Section 15a of the Nuclear Energy Act. This means that the legislative amendment may result in an operating life extension that falls under the guidelines.

Espoo Compliance Committee

The proposal for an operating life extension displays certain similarities with the situation regarding the operating life extension of the Kozloduy nuclear power plant in Bulgaria[6]. This involved operating life extensions for two of the six reactors. A total of 280 measures needed to be performed on the reactors, of which 15% required physical intervention. However, Bulgaria took the position that the activities in question were covered by the 10EVA (mandatory ten-yearly periodic safety review), rather than linking them to the operating life extension (the LTO licence). Bulgaria asserted that those changes were already permitted under the existing licence. However, the Espoo Compliance Committee disagreed and concluded that all physical measures, including small ones, need to be considered. Neighbouring country Romania, for its part, was of the opinion that an EIA procedure should have been completed prior to the decision on the operating life extension of Kozloduy. After all, so Romania reasoned, a longer operating life (with limited physical changes to the nuclear power plant) still represents a longer-term potential transboundary

[3] wetten.nl - Regeling - Verdrag inzake milieu-effectrapportage in grensoverschrijdend verband - BWBV0002731 (overheid.nl)

[4] 2106311_E_WEB-Light.pdf (unece.org)

[5] Espoo guidelines, Section 33

[6] ece_mp.eia_ic_2023_6_e.pdf (unece.org)

environmental impact. The Espoo Compliance Committee agreed and concluded that Bulgaria should indeed have completed an EIA procedure prior to deciding on the operating life extension of Kozloduy. The Meeting of the Parties confirmed these findings.

1.3.2.2 Communication of the European Commission

As indicated, the technical studies designed to demonstrate whether a safe operating life extension of the Borssele nuclear power plant beyond 2033 is possible are still under way as this legislative amendment is being prepared. Given the current status of this legislative amendment, it is not yet certain whether physical changes to the nuclear power plant are necessary for an operating life extension. Such physical changes are important, inter alia, for the question of whether an environmental impact assessment must be performed for an operating life extension.

In a communication, the European Commission has stated the following in this regard: *"Lifetime extension and long-term operation are specific cases. Theoretically, both could occur without works but, in practice, in the Members States of the EU, it can be expected that they are accompanied by works.*[7]*"*. The guidelines also state that it is unusual for an operating life extension to be achieved without physical changes. In addition, it may be inferred from the guidelines that under certain circumstances, a transboundary EIA is required, even in the absence of physical changes[8]. These passages reinforce the assumption that an environmental impact assessment will need to be performed for the operating life extension.

The question has arisen whether an environmental impact assessment for plans (plan EAI) should have been carried out for the legislative amendments as referred to in the SEA Directive (Strategic Environmental Impact Assessment Directive)[9]. After all, it follows from the European ruling on the Nevele wind farm that the SEA Directive can also apply to plans and programmes which are established under an act of parliament[10]. In the government's judgement, however, the SEA Directive does not apply to acts of parliament in a formal sense, because these do not fall under the definition of the term "plans and programmes" in Section 2(a) of the SEA Directive.

1.3.2.3 Aarhus Convention

Details of the Convention
The Aarhus Convention concerns the accessibility of the relevant environmental information of a plan or project.[11] Article 6 of the Convention sets out the requirements that must be met. The Convention requires European member states to make public participation and decision-making about environmental information equally accessible to all residents. Article 8 of the Convention is also relevant to the operating life extension of the Borssele nuclear power plant and the legislative amendment that would be required to that end. This article stipulates: *Public participation during the preparation of executive regulations and/or generally applicable legally binding normative instruments.* The legislative amendment represents such a legal instrument and under Article 8 (and also Article 6) of the Convention, public participation in and access to environmental information are therefore an important pillar in the process.

Compliance Committee
The Convention also establishes a so-called compliance committee, the ACCC. In communication ACCC/2014/104, the compliance committee issued its findings regarding the granting of a permit for the extension of the nuclear power plant's design lifetime in 2013. The ACCC concluded that insufficient opportunity had been given for public participation with regard to the inclusion of Section 15a in the Nuclear Energy Act in 2010. The ACCC recommended providing for early and effective public participation in decisions regarding the reconsideration or alteration of the duration of nuclear activities that may have significant consequences for the environment. This provides an extra reason to institute an EIA procedure including public participation at this stage.[12]

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[7] Commission notice regarding application of the Environmental Impact Assessment Directive (Directive 2011/92/EU of the European Parliament and of the Council, as amended by Directive 2014/52/EU) to changes and extension of projects - Annex I.24 and Annex II.13(a), including main concepts and principles related to these.

[8] Section 49 of the guidelines

[9] Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment (OJ 2001, L 197, p. 30)

[10] European Court of Justice EU, 25 June 2020, C-24/19

[11] wetten.nl - Regeling - Verdrag betreffende toegang tot informatie, inspraak in besluitvorming en toegang tot de rechter inzake milieuaangelegenheden - BWBV0001700 (overheid.nl)

[12] ACCC/C/2014/104 Netherlands | UNECE

Participation
In this first phase, the requirements of the convention are being met by making the draft legislative proposal and the EIA report available for inspection, along with the related documents, and giving everyone the opportunity to respond with statements of views. These statements of views will be considered during the further legislative process. A further opportunity for public participation will be provided in the second phase of the licensing process (see also Section 1.3.5 below).

1.3.2.4 The European ruling on the Doel nuclear power plant

The proposal for an operating life extension displays certain similarities with the situation concerning the operating life extension of the nuclear power plant in Doel (Belgium)[13]. This procedure related to a ten-year extension of electricity production from two nuclear power plants in Doel, for which a legislative amendment was required. According to the ruling by the European Court of Justice, the measures determined by the Belgian Parliament (the legislative amendment) and the modernisation works on the nuclear power plants that were an inseparable part of those measures together formed part of the licensing procedure for one and the same 'project' in the sense of Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (OJ EU 2012, L 26) (the EIA directive). The Belgian Constitutional Court subsequently ruled that the adoption of the legislative proposal should have been preceded by an environmental impact assessment and the consultation of the public on the principle of extension and on the consequences of that extension in the matter of the modernisation and safety works.

It may be concluded from this ruling by the European Court of Justice on this operating life extension (the 'Doel judgment') that the legislative amendment for the operating life extension of Borssele nuclear power plant may be classified as the first phase in granting permission for a project in the sense of the EIA Directive. The permit is the second phase. In other words, having regard to this judgment, the permit application and legislative amendment are to be jointly regarded as a single (phased) licensing procedure for the project (the operating life extension).

1.3.3 A project EIA in two phases

Based on the section above, this EIA procedure for the potential operating life extension is divided into two phases: the legislative amendment in Phase 1 and the licensing process in Phase 2. The steps in the procedure are described in Figure 1-1 below. Because a project EIA procedure does not need to be submitted to the EIA Committee, but we do acknowledge the societal importance of a nuclear energy project, we will be asking the Committee for its opinion at various points in the procedure, as indicated in the figure below. The two phases of the EIA procedure are illustrated by Figure 1-1.

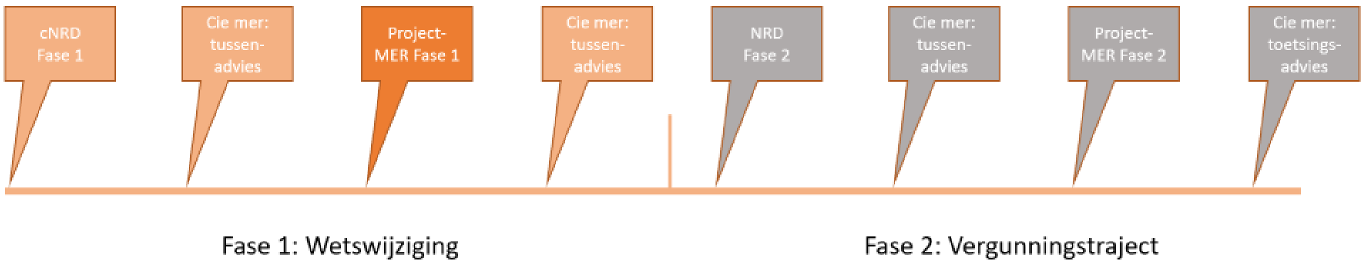

Figure 1-1 EIA procedure and (interim) steps for the potential operating life extension

13 CURIA - Documents (europa.eu)

Phase 1: Exploratory EIA for the legislative amendment
The first step in the decision-making on the operating life extension is to amend the Nuclear Energy Act. In line with the opinion of the EIA Committee, the environmental impacts of the nuclear power plant in the existing situation will be explored in the EIA Phase 1 for the legislative amendment. In addition, where possible, the EIA will look ahead to future environmental impacts after 2033: which environmental aspects contain the potential for negative impacts and what are the focal points requiring attention for the next phase? The EIA concludes with an overview of the environmental aspects to be monitored and an overview of focal points requiring attention in the second phase (see below).

Phase 2: EIA for the permit application for the operating life extension
The fact that the Nuclear Energy Act is being amended does not automatically mean that the nuclear power plant will be allowed to remain operational for longer. There are technical studies currently under way to establish whether it is technically possible and feasible to keep the nuclear power plant safely operational after 2033 and which changes to and investments in the nuclear power plant will be required to that end. After that, the operator of the nuclear power plant must submit a permit application to the ANVS. This will require the operator to investigate the environmental impacts as part of the EIA Phase 2. This environmental study will be more concrete and more detailed than the study in Phase 1 and will be more focused on the situation of the nuclear power plant remaining operational after 31 December 2033. This is because when assessing the environmental impacts in this phase, it will be possible to also consider the results of the technical studies, along with the required changes to the nuclear power plant (if the studies call for them).

The EIA procedure ends upon the delivery of EIA Phase 1 and 2.

1.3.4 Steps in the EIA procedure

The steps in the formal EIA procedure for the amendment of the Nuclear Energy Act are as follows:
1. Initiator draws up draft Memorandum on Scope and Level of Detail.
2. The competent authority issues public notice of the intention to amend the Nuclear Energy Act, including the presentation of the draft Memorandum on Scope and Level of Detail for inspection. The draft Memorandum on Scope and Level of Detail was available for inspection between 31 May 2023 and 11 July 2023.
3. Request for statements of views, consultation of (legal) advisors and stakeholders.
4. The competent authority requests an opinion from the EIA Committee on the draft Memorandum on Scope and Level of Detail. On 12 October 2023, the EIA Committee issued its advice on the scope and level of detail of the EIA Phase 1.
5. Advice (response memorandum) issued by the competent authority to the initiator about the scope and level of detail of the EIA Phase 1 based on, inter alia, statements of views and opinions. This response was sent in a Letter to Parliament on 25 March 2024.
6. Initiator draws up EIA Phase 1.
7. Initiator presents EIA Phase 1 to the competent authority.
8. Public announcement of the draft legislative amendment concurrently with EIA Phase 1.
9. Opportunity for all to submit statements of views on the draft legislative amendment and EIA Phase 1. In addition, opinions will be requested from the legal advisors and the EIA Committee with regard to EIA Phase 1.
10. The response memorandum will respond to the statements of views, and contain supporting evidence on the handling of public participation.
11. Approval of the legislative amendment based on EIA Phase 1 and the related statements of views, opinions and response memoranda. No legal recourse is available against a legislative amendment. A legislative amendment is not a decision in the sense of the General Administrative Law Act.
12. Monitoring and evaluation of the environmental impacts, following the implementation of the project. 14

Figure 1-2 presents these procedural steps in diagrammatic form. The steps already completed are explained in more detail in Sections 1.3.5 and 1.3.6.

[14] The monitoring and evaluation of the environmental impacts of the operating life extension will take place only after EIA Phase 2.

Figure 1-2 Schematic representation of the EIA procedure

1.3.5 Publication of the Intention and Proposal for Public Participation

The Ministry of Economic Affairs and Climate Policy and the Ministry of Infrastructure and Water Management consider participation with stakeholders and interested parties in the proposed legislative amendment at an early stage to be very important. The thinking behind this, based on experience, is that intensive collaboration with local communities and other stakeholders leads to better projects that enjoy greater acceptance and support. Added to that, such collaboration serves to increase the understanding of each other's interests and points of view.

Participation plan
Between January and April 2023, a plan[15] was drawn up with the Ministry of Economic Affairs and Climate Policy and the Ministry of Infrastructure and Water Management, in close consultation with the affected municipalities and provincial authority, in order to define participation and communication around this process. This plan focuses on national, regional and local dimensions of this proposal.

An important principle of the participation and communication plan referred to above is that everyone has the opportunity to obtain sufficient knowledge and information in order to be able to form an opinion and take part in the participation process. The most important means for keeping the public up to date is the website www.overkernenergie.nl. Information meetings at international, national and regional level will be organised around the procedural steps to be taken and around major (political) decisions. There will be ongoing work to build and transfer knowledge to all relevant stakeholders by means of webinars and knowledge clips. Finally, in the longer term a physical information centre will be set up in which information will be available for residents and where there will also be staff on hand to answer questions.

[15] Participatie- en communicatieplan Kernenergie Deel 1 & Participatie- en communicatieplan Kernenergie Deel 2

Formal participation
There are a number of statutory procedures for taking decisions. These are set out in the Environment and Planning Act, the Nuclear Energy Act and the General Administrative Law Act. Facilitating public participation is a compulsory part of these procedures. This means that anyone who wants to can respond at specific points in time.

The goal of participation around the Memorandum on Scope and Level of Detail was to catalogue information, local knowledge (specific characteristics of the local region), focal points requiring attention, ideas and opportunities. These could relate to the environmental impacts to be identified, the evaluation framework or the participation process itself. One purpose of participation is to ensure that the interests of both national and international stakeholders are included in the decision-making. In Section 1.3.6 below, we discuss the results of the participation process during the Memorandum on Scope and Level of Detail phase in more detail.

The next step in the formal participation process is when the EIA Phase 1 is presented for inspection as an annex to the draft legislative amendment. The draft legislative amendment and the EIA will be made available for inspection for six weeks, in accordance with the General Administrative Law Act. Anyone, i.e. residents, organisations and international stakeholders, will have the opportunity to respond to the documents at that time. As in the Memorandum on Scope and Level of Detail phase, the statements of views received will then be published in a response memorandum, along with responses to those statements of views.

1.3.6 Memorandum on Scope and Level of Detail & EIA phase

Memorandum on Scope and Level of Detail phase
As a first step in the procedure for an Environmental Impact Assessment, a so-called (draft) Memorandum on Scope and Level of Detail has been drawn up. *N.B.: Previously, the Memorandum on Scope and Level of Detail was referred to as a draft Memorandum on Scope and Level of Detail, but the outcomes and responses to it have been incorporated directly into this EIA, which means there is no final Memorandum on Scope and Level of Detail.* The envisaged research design for the EIA is included in the Memorandum on Scope and Level of Detail. This Memorandum on Scope and Level of Detail was formally available for inspection between 31 May 2023 and 11 July 2023. During those six weeks, everyone – both in the Netherlands and in the relevant neighbouring countries – had the opportunity to submit a statement of views in response to the research design. The independent EIA Committee also issued an opinion on the Memorandum on Scope and Level of Detail on 12 October 2023.

Response to the draft Memorandum on Scope and Level of Detail
In total, 170 regular statements of views were received. Of those, 23 originated from organisations such as municipalities and interest groups, and 147 from private individuals. Of the statements of views submitted from the Netherlands, most (53) originated from Zeeland. Fifteen statements of views were signed multiple times. Other statements of views originated not from the Netherlands but from neighbouring countries.

- 82 statements of views originated from Germany.
- Four from Belgium.
- One from Luxembourg.
- One from Austria.
- And one from Denmark.

The competent authority (the Ministry of Infrastructure and Water Management) has drawn up a response memorandum.[16] In it, responses are given to all the points in the statements of views received, along with a response to the opinion of the EIA Committee.

[16] Reactienota zienswijzen concept-Notitie Reikwijdte en Detailniveau Kernenergiewetherziening tbv bedrijfsduurverlenging kerncentrale Borssele | Tweede Kamer der Staten-Generaal

Action in response to the opinion of the EIA Committee
The EIA Committee issued its opinion on the Memorandum on Scope and Level of Detail on 12 October 2023.[17] In its opinion on the Memorandum on Scope and Level of Detail, it considered the intended research design and also made several recommendations on how to improve the quality and transparency of decision-making on the legislative amendment.

The opinion of the EIA Committee consists of several points which have been incorporated directly into the EIA. The most relevant points from the opinion are shown below, along with how they have been incorporated into this EIA.

<u>Consent for a potential permit application or more?</u>
The EIA Committee expresses its uncertainty as to whether the legislative amendment is solely intended to remove an obstacle to the permit application or whether the legislative amendment implies approval for an operating life extension in principle. It must be clearly stated that the legislative amendment does not automatically mean that the nuclear power plant will be allowed to remain operational for an extended period of time. The legislative amendment purely removes the obstacle to a new permit application and thus facilitates the possibility of granting a permit for a longer operating life than 31 December 2033. Naturally, it will need to be demonstrated that this is possible safely and responsibly, by means of technical studies but also in-depth environmental studies.

<u>Regional strategic choices to be made by central government</u>
The EIA Committee points out that it is for the government to make strategic choices about the energy transition in the Borssele region. There are multiple projects in that region which fall under the National Coordination Scheme (RCR) and there is a lack of an overarching vision, according to the Committee. It goes on to assert that strategic choices in the area may not be left to a private party when it comes to submitting a permit application for an operating life extension in the future. Section 2.4 of this EIA describes the relevant National Coordination Scheme projects in the vicinity of the Borssele nuclear power plant and how these projects are viewed in relation to one another. In addition, the national government emphasises that strategic choices in a particular region cannot and need not be made by a private party.

<u>Wider decision-making</u>
The EIA Committee requests clarification as to which (other) decisions are needed in order to facilitate an operating life extension. It also calls for consideration for coherence between the legislative amendment on the one hand and the EIA procedure on the other.

Section 2.3 of this EIA contains a timeline showing which steps need to be taken throughout the process. The timeline encompasses the establishment of the Memorandum on Scope and Level of Detail, the EIA, the legislative amendment, the steps to obtain approval for the legislative amendment, the studies that need to be commissioned for the permit application and at what point in time (approximately) an application will be submitted to the ANVS for approval. The timeline also shows other procedures in which nuclear energy plays a role (such as the National Energy System Plan, the National Energy Network Programme, NOVEX and possible international processes).

<u>Alternatives and reference: different approach needed</u>
The EIA Committee asserts that there is no value in reviewing the alternatives set out in the Memorandum on Scope and Level of Detail. The Memorandum on Scope and Level of Detail assumes three alternatives as regards the measurement of environmental impacts: allowing the nuclear power plant to remain operational for ten more years, for twenty more years or indefinitely. In the words of the Committee: *"The question is whether a comparison between (...) the alternatives and an uncertain (and hypothetical) development of the Borssele area and its surroundings in the distant future (in the period from 2033 to 2053) can offer decision-making information for the legislative amendment that is both distinctive and meaningful. In addition, describing the reference situation accurately would seem to be a complex undertaking."*

The EIA Committee instead proposes a different approach. It prefers that the EIA should examine the existing environmental impacts of the Borssele nuclear power plant – after all, these are only known in a fragmentary and limited manner. And, as multiple statements of views attest, those in the Borssele area would benefit from this information. Alongside the existing environmental situation, the EIA Committee recommends extrapolating these results to 2033 and beyond where possible. This would shed light on whether (environmental) hurdles are likely to

[17] 3723_rd_advies_reikwijdte_en_detailniveau.pdf (commissiemer.nl)

arise at a later date, the cumulative effects of which are no longer acceptable, and which might require further attention at the time of the permit extension in a number of years' time. All of this results in an agenda listing environmental focal points which can serve as a guide for the (environmental) studies in the next phase – i.e. following the legislative amendment for the licensing process.

This alternative approach has been fully adopted in this EIA. This means that the EIA is no longer based on the three alternatives defined previously, but instead focuses on the environmental impacts of the existing situation, a look ahead to how those environmental impacts may develop over time, and which considerations this throws up for a potential future permit application and permit award.

1.4 Stakeholders

In order to obtain a clear picture of the environmental impacts of the legislative amendment and in view of the obligations regarding (transboundary) public consultation, the government has decided to complete an EIA procedure during the preparations for this legislative amendment. In this EIA procedure, the Minister of Economic Affairs and Climate Policy and the State Secretary for Infrastructure and Water Management together represent the competent authority for the legislative amendment (they will jointly submit the legislative proposal to Parliament). To ensure an appropriate separation of roles, the Ministry of Economic Affairs and Climate Policy will act as the initiator and the Ministry of Infrastructure and Water Management will act as the competent authority in this EIA. Table 1-1 provides an overview of the initiators and competent authorities for the EIA and the 'mother procedure' for each phase.

Table 1-1 Initiator and competent authority for EIA Phases 1 and 2

	Phase 1	
	Initiator	**Competent authority**
Legislative amendment	The Ministry of Economic Affairs and Climate Policy and the Ministry of Infrastructure and Water Management.	Government and Parliament
Project EIA	Ministry of Economic Affairs and Climate Policy	Ministry of Infrastructure and Water Management
	Phase 2	
	Initiator	**Competent authority**
Permits	Operator of the Borssele nuclear power plant	ANVS
Project EIA	Operator of the Borssele nuclear power plant	ANVS

A legislative procedure needs to be completed in order to amend Section 15a of the Nuclear Energy Act. The Minister for Climate and Energy Policy together with the State Secretary for Infrastructure and Water Management will prepare a legislative proposal. The legislative proposal will be sent to the Advisory Division of the Council of State (the Division) for its opinion. The opinion of the Advisory Division may result in amendments to the legislative proposal or the explanatory notes. The legislative proposal will then be presented to the House of Representatives of the States General. The House may propose changes (right of amendment). If the House adopts the legislative proposal (and any proposed amendments), it will be sent to the Senate of the States General. The Senate can adopt or reject the legislative proposal. If the legislative proposal is adopted, it will be ratified and published in the Bulletin of Acts, Orders and Decrees of the Kingdom of the Netherlands. After this, the act will come into force.

The plant is owned by N.V. Elektriciteits-Produktiemaatschappij Zuid-Nederland (EPZ). EPZ is jointly owned by ZEH Energy B.V. and Energy Resources Holding BV.

The State Secretary for Infrastructure and Water Management has requested that the EIA Committee provide guidance on the contents of the forthcoming IEA Phase 1. The EIA Committee is an independent body, established by law, that is tasked with advising on the content and quality of EIA reports. It appoints a working group of independent experts for each project. The competent authorities (the Senate, House of Representatives, and the government) are responsible for taking decisions on the legislative amendment and the permit (the ANVS).

Seven National Coordination Procedures for major energy projects are currently under way in the municipality of Borsele. The Borsele municipality and the Province of Zeeland and the Scheldestromen Water Board do not have a direct role in this EIA. These parties can, however, submit statements of views.

1.5 Notes for readers

This EIA for the amendment of the Nuclear Energy Act consists of a general section containing background information about the reasons behind this EIA and a section containing more specialised information about nature, water, radiological effects, soil, safety and noise.

The scope of this EIA is explained in chapter 1, including the requirement for an EIA, the procedure and participation.

Chapter 2 provides insight into decision-making on the Borssele nuclear power plant and nuclear energy over time. Chapter 2 also contains a description of nuclear energy's role in the energy mix and a timetable setting out information about what will be decided with regard to electricity production, by means of which decision and in what order.

Chapter 3 contains a general description of the Borssele nuclear power plant, the nuclear fuel chain and CO_2 emissions during the life-cycle of nuclear energy.

Chapter 4 describes the legislative proposal for the proposed activity.

Chapter 5 provides an introduction to other chapters in this EIA, which outline the methodology used and the structure of this EIA.

Chapters 6 to 12 provide a survey of the environmental impacts per environmental aspect (nature, radiation protection, nuclear safety, water, safety & health, soil and noise), including a comprehensive and accessible summary of the Borssele nuclear power plant's existing environmental impacts. This is followed by an extrapolation of the environmental impacts for the post-2033 period (where possible). The environmental chapters conclude with an agenda listing environmental focal points requiring attention in a potential EIA Phase 2. The transboundary environmental impacts are also included in the relevant themed chapters.

The EIA concludes with a summary chapter which provides an overview of the environmental impacts of the existing situation and the extrapolation, and summarises the environmental focal points to be monitored in EIA Phase 2. Possible gaps in knowledge at the present time are also highlighted here.

2 Energy mix, procedures and decisions

Chapter 2 provides insight into decision-making on the Borssele nuclear power plant and nuclear energy over time. Section 2.1 describes the decision-making specifically for the Borssele nuclear power plant and provides an overview of the operating life and the associated permits. Section 2.2 contains a description of the benefits of nuclear energy as part of the Netherlands' energy mix. Section 2.3 outlines the products and decisions about nuclear energy over. Section 2.4 explains legislation and important policy frameworks, and also provides an overview of the projects in Borsele municipality that fall under the National Government Coordination Scheme.

2.1 Background to decision-making

On 3 July 1973, the Borssele nuclear power plant supplied its first electricity to the grid; commercial operation began in October 1973. This means that the nuclear power plant has now been operational for over fifty years.

Following the nuclear disaster at Chernobyl (on 26 April 1986), a team from the International Atomic Energy Agency (IAEA) critically investigated the plant and drew up a list of deficiencies. Shortly after the Chernobyl disaster, the Electricity Plan for 1987-1996 was agreed by the Samenwerkende Elektriciteits-Productiebedrijven (SEP, Dutch Cooperating Electricity Production Companies).The plan assumed that the Borssele nuclear power plant would close at the end of 2003. In 1991, the operator of the plant had received approval from the SEP to invest in a number of changes. In order to be able to recoup the investments in the modernisation, it was calculated that the plant would need to remain operational for longer, until 2007. In 1994, the House of Representatives of the States General nevertheless voted to close the nuclear power plant on 31 December 2003. In 2000, the Council of State decided that the proper procedures had not been followed and that the plant could stay open. The first Balkenende cabinet decided that Borssele could remain operational for longer. A court later ruled that the government had never made valid arrangements regarding the closure in 2004.

In early 2004, the then Secretary of State for the Environment announced that he was preparing a plan to change the permit for Borssele. He mentioned the end of 2013 as the end date for the plant's operating life, in line with the coalition agreement (second Balkenende cabinet, 2003). In February 2005, the Secretary of State indicated that the nuclear power plant would be permitted to remain operational beyond 2013. In 2006, the 'Borssele Covenant' was signed. The government assented to the Borssele nuclear power plant remaining operational until the end of 2033, provided it was among the 25% safest nuclear power plants of equivalent type in Europe, the United States and Canada. In order to assure this end date, a provision was then added to Section 15a of the Nuclear Energy Act stipulating that the permit granted for maintaining the Borssele nuclear power plant in operation as regards the release of nuclear energy would expire on 31 December 2033.

Section 15a of the Nuclear Energy Act further states that no permit application will be considered for the plant to release nuclear energy after 2033. An operating life extension beyond 31 December 2033 will require an amendment to the Nuclear Energy Act. On 23 June 2022, the Minister for Climate and Energy Policy announced: "The Borssele nuclear power plant will remain operational for longer. The government sees other possibilities for nuclear energy in addition to solar, wind and geothermal energy". Technical studies are currently under way. These studies are exploring whether an operating life extension beyond 2033 can be achieved safely and what investments would be required. The initial barrier to an operating life extension that needs to be removed is to amend the Nuclear Energy Act.

2.2 Energy mix

In a Letter to Parliament of 9 December 2022, the Minister for Climate and Energy Policy provided further detail on the agreements in the Rutte IV Coalition Agreement relating to nuclear energy. *"As part of the transition to a climate-neutral Netherlands in 2050, the government has stated the ambition of making our country's electricity production carbon neutral by 2040 at the latest. Nuclear energy can make an important contribution to this goal."*

Some of the arguments as to why nuclear energy *can* make a contribution to a robust energy system are set out in the sections below. This procedure does not address the question 'why include nuclear energy in the energy mix?'. There are other procedures which consider the Netherlands' energy system more widely. In those procedures, multiple questions/sub-questions regarding the role of nuclear energy (nuclear energy as part of the mix, dealing with radioactive waste, the relationship to nearby projects, the potential construction of new nuclear power plants) are answered. The question of whether nuclear energy should be part of the energy mix based on environmental considerations will be addressed in a procedure which the Ministry of Economic Affairs and Climate Policy is expected to elaborate in the course of 2024.

2.2.1 The Netherlands' climate objective

The Netherlands' climate objective for 2050 is to be climate neutral; for 2035, the objective is for no CO_2 to be emitted in the production of electricity. These objectives are also set out in the coalition agreement of the Rutte IV cabinet. Thus, the coalition agreement states the commitment to climate neutrality by 2050; the goal is to achieve a 55% CO_2 reduction by 2030.

In order to achieve these objectives, the Dutch government is seeking to establish a climate-neutral energy mix. The energy mix is the combination of different energy sources (such as natural gas, solar, wind, nuclear) and energy carriers (such as hydrogen). While the need for energy will remain, and indeed increase, there will be a transition to energy sources that do not emit greenhouse gases. In order to reduce the use of natural gas for heat generation, there will be a drive for electrification (for example, in households and industry). In this way, the government aims to cut the use of fossil fuels while at the same time assuring reliability of supply and the affordability of energy. Since increased electrification will result in an ever-increasing demand for electricity, all renewable energy sources will be needed in order to both meet demand and achieve the CO_2 objectives. In addition, efforts will be made to reduce energy consumption by businesses and households in order to lessen the increasing pressure on the electricity grid in the long-term and to make it easier to meet energy demand sustainably.

The National Energy System Plan (NPE), approved in December 2023, describes the composition of the energy mix in more detail. The NPE sets out a vision of an energy system for the Netherlands that corresponds with a climate-neutral society by 2050. In order to achieve these objectives, it will be necessary to scale up solar, wind and nuclear energy sources to their maximum capacity. For nuclear energy, in concrete terms scaling up means constructing two new nuclear power plants and extending the operating life of the Borssele nuclear power plant, provided it can be demonstrated that this can be done *safely*. The related National Energy Network Programme (PEH) describes the infrastructure required for the energy system of the future in more detail. Both programmes focus on a responsible approach to safety and health in the energy transition as a precondition. Civil society organisations and citizens have also been involved in these programmes in order to generate support for and acceptance of the choices made.

These two programmes do not address the question of whether nuclear energy should be part of the energy mix, based on environmental considerations. The answer to that question will follow in a procedure which the Ministry of Economic Affairs and Climate Policy is expected to elaborate in the course of 2024.

2.2.2 Growing demand for electricity

Based on predictions by the Dutch government and the results of the Climate and Energy Outlook, the Netherlands faces the major challenge that the demand for CO_2-neutral energy will increase significantly in the near future. In order to maintain progress on making electricity consumption more sustainable, it is important that there should be sufficient supply to meet rising demand for CO_2-neutral electricity.

The Netherlands currently generates electricity from the following sources: wind, solar, gas, coal, biomass, hydroelectric and nuclear. In 2021, the total supply of electricity was 122 billion kWh, 1 billion kWh more than in 2020. Domestic electricity production fell by 2 billion kWh, while imports increased by 3 billion kWh. The reason for this reduction is that electricity production from fossil sources fell by more than the increase in electricity production from renewable sources. The fall in electricity production from fossil sources (a reduction of 22% to 55.3 billion kWh) was largely caused by high gas prices. An additional effect of high gas prices was that significantly more electricity was generated from coal (an increase of 72% to 16.5 billion kWh). Due to factors including high gas prices, there was also an increase in electricity production from renewable sources (an increase of 18% to 43.3 kWh). The reduction in domestic electricity generated from fossil sources and the increase in electricity imports demonstrates the importance of stable and sufficiently large electricity production. Extending the operating life of the nuclear power plant will contribute to the supply of CO_2-free electricity after 2033.

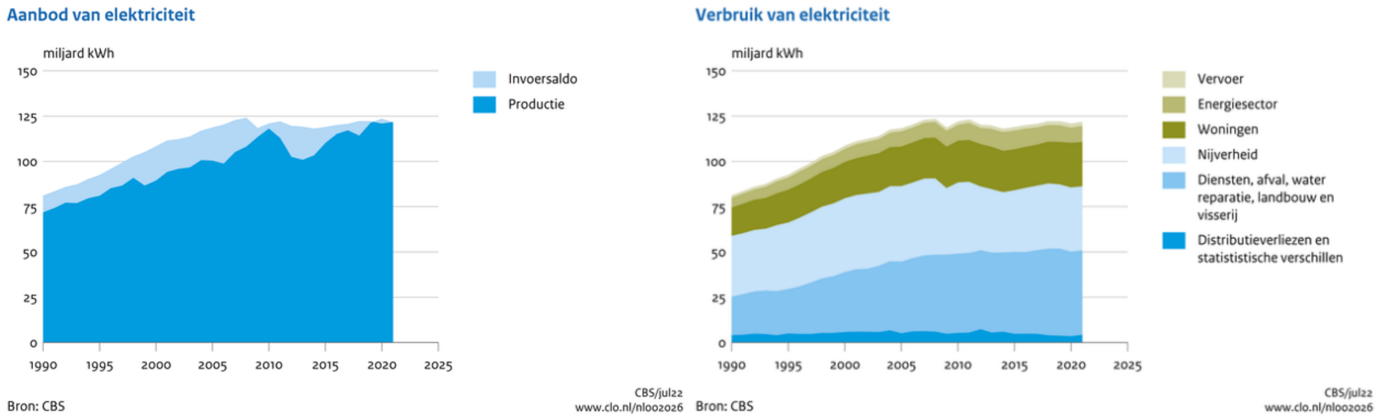

Figure 2-1 Supply (left) and consumption (right) of electricity. Source: Statistics Netherlands

The growing demand for electricity is considered in the Climate and Energy Outlook. This is an annual publication outlining developments in greenhouse gas emissions and the past, current and future energy system in the Netherlands. The Climate and Energy Outlook evaluates proposed developments based on the important national and European climate and energy objectives.

The Climate and Energy Outlook states that increasing electrification of consumption in the commercial sector (e.g. industrial enterprises) and mobility will result in a significant rise in the demand for electricity. That also includes electrification in general, such as water electrolysis and hybrid boilers. This development calls for sufficient reliability in the supply of electricity. In parallel to that is the expectation that in the coming years, the quantity of electricity generated within the Netherlands will fall, for instance as a result of the ban on generating electricity from coal after 2030.

The electricity that is currently being generated by coal-fired power stations will have to be produced from a different source, in view of the growing demand for electricity. In order to meet the climate objective, that will have to be a CO_2-neutral source of electricity.Nuclear energy could make a substantial contribution in this regard.

2.2.3 Nuclear energy in the energy mix

The results of the Climate and Energy Outlook 2022 reveal that we will need all available CO_2-neutral energy sources in order to achieve the climate objectives. In concrete terms, including nuclear energy in the energy mix will mean constructing two new nuclear power plants and extending the operating life of the Borssele nuclear power plant, provided it can be demonstrated that this can be done safely. The Borssele nuclear power plant has a net electrical capacity of 485 megawatts (MW) of electricity and generates approximately 3.8 billion kWh of electricity every year. In total, this is approximately 3% of the electricity consumed by the Netherlands annually. Alongside sources such as offshore wind, solar roofs, geothermal, green gas, aquathermal and hydrogen, nuclear energy can make a significant contribution to the objective of generating exclusively CO_2-neutral electricity by 2035.

No CO_2 is emitted when generating electricity in a nuclear power plant. However, CO_2 is emitted during the construction and eventual decommissioning of nuclear power plants, in the mining and transport of uranium and in the processing and storage of nuclear waste. An international panel of climate scientists has calculated that the total greenhouse gas emissions of nuclear energy over the entire life-cycle is approximately equivalent to the emissions of wind energy and actually lower than those of solar energy (see also Section 3.3. The smaller physical footprint of nuclear energy compared to wind energy and solar energy is evident.

Generally speaking, nuclear energy is not more expensive than renewable sources such as wind and solar. This is primarily because building energy infrastructure, balancing the grid and meeting the connection costs of wind and solar require significant investments that are currently paid for by network operators and consumers. If these costs are taken into account, the cost of nuclear energy is comparable to that of wind and solar energy. Extending the operating life of the existing nuclear power plant, which requires no additional construction and decommissioning activities – depending on the measures that need to be taken – represents one of the cheapest and fastest ways of continuing to generate CO_2-free electricity.

2.2.4 Grid stability and reliability of supply

Now that the electricity supply in the Netherlands relies more heavily on renewable sources such as wind and solar, a large unit such as a nuclear power plant can contribute to the stability of the grid. All the electricity that is consumed at any one time needs to be generated somewhere else virtually simultaneously. If not, power cuts may result. However, in the case of wind turbines and solar panels, we cannot assume constant production because the sun does not shine 24 hours per day and sometimes the wind dies down completely. In the winter months in particular (as a result of days of cloud cover and/or precipitation), this can lead to a reduced supply of electricity. Due to these fluctuations, it is not possible to guarantee reliability of generation and supply of electricity.

Large units like nuclear power plants are important for delivering sufficient short-circuit power for the fail-safes in the high-voltage grid to operate satisfactorily.

Nuclear power plants are a proven technology that can supply electricity 24 hours per day, regardless of the season and weather conditions, day and night, making it a reliable source of electricity in periods when renewable energy sources such as wind and solar are not available. Compared to other energy sources, nuclear power plants require little space for the power they are able to generate.

2.2.5 Dependence on foreign countries

The Netherlands is dependent on Russia for gas. With Russia restricting gas supplies due to the war in Ukraine, the Netherlands faced a potential energy shortfall in the winter of 2022/2023. The price of gas reached an unprecedented peak in the summer of 2022, as a result of the inadequate supply of gas and European countries bidding against one another.

Besides gas, the Netherlands is also dependent on foreign countries for imports of the raw materials required for making solar panels and/or wind turbines. The Netherlands is also dependent on deliveries from abroad when it comes to nuclear energy, in this case for uranium, a raw material which is not available in the Netherlands.[18]

The Netherlands will remain dependent on foreign countries for its energy supply. But by opting for diversification of energy sources, such as a combination of solar, wind and nuclear, the Netherlands will become less dependent on a single source. In addition, using nuclear energy will reduce the Netherlands' dependence on imported electricity.

2.3 Products and decisions about nuclear energy over time

Nuclear energy has only re-emerged as a relevant energy generation method in the Netherlands in recent years. Whereas in previous decades, efforts were directed at reducing the role of nuclear energy in the energy mix (see also the provision of Section 15a of the Nuclear Energy Act stipulating the closure of the Borssele nuclear power plant on 31 December 2033), it now once again appears to be a promising solution for delivering the energy mix.

In accordance with the opinion of the EIA Committee, in this section we consider all the decisions that will take place or have taken space in relation to nuclear energy. Securing an operating life extension for Borssele is only one small part of the measures to achieve the government's climate objectives. The total of new or existing policy documents establishing frameworks and goals for the Netherlands' energy mix also extends beyond just this EIA procedure for the operating life extension. They include several political decisions, several administrative agreements, but also concrete plans to increase the share of nuclear energy in the energy mix. Table 2-1 provides a summary of the context of which operating life extension is a part.

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[18] There is currently no shortage of uranium. There is also a diversity of suppliers, with no country having a monopoly on this raw material. In addition, uranium can be stored for quite some time without incurring significant risks and without the material degrading. This means it is possible to build up long-term stocks.

Table 2-1 Products relating to nuclear energy over time: divided between products at the level of national government and elements of the operating life extension

Products at the level of national government	Year	Notes	Dependencies
Coalition Agreement Rutte IV	2021	The Coalition Agreement for the fourth Rutte cabinet includes the objective of keeping the Borssele nuclear power plant operational and constructing two new nuclear power plants.	Already completed. Work is currently under way at the Ministry of Economic Affairs and Climate Policy to accomplish these two goals.
Letter to Parliament on nuclear energy, 9-12-2022	2022	The Letter to Parliament dated 9-12-2022 again sets out the government's goals: two new nuclear power plants and keeping the Borssele nuclear power plant operational. It once again emphasises the essential importance of keeping the Borssele nuclear power plant operational: the plant is already there, its operating life is probably not yet over and it ties in well with a green energy system.	Already completed. Work is currently under way at the Ministry of Economic Affairs and Climate Policy to accomplish these two goals.
National Energy System Plan (NPE)	2023	A vision document laying out scenarios for the energy system of the Netherlands in 2050. It includes nuclear energy, in line with the objective set out in the Coalition Agreement for the fourth Rutte cabinet and the Letter to Parliament of 9 December 2022.	Already completed and now represents the current policy framework for energy projects in the Netherlands.
National Energy Network Programme (PEH)	2023	The elaboration of the NPE: it highlights spatial planning opportunities/bottlenecks in the national energy network in various energy scenarios. Nuclear energy is part of one of those scenarios.	Already completed.
TenneT system study	2024	The TenneT system study investigates the potential for new energy sources to be incorporated into the energy system. The study highlights the fact that in the Borssele region, the incorporation of new energy sources will become problematic after 2035.	The Borssele nuclear power plant is already part of the energy system in the Borssele region. This will not change. However, if Borssele remains operational for longer it will impose additional pressure on the high-voltage grid because approximately 500 MW of additional energy will be added after 2033.
Broader consideration of the utility and necessity of nuclear energy in environmental terms	2024	The Ministry of Economic Affairs and Climate Policy will provide more evidential support for its position on the utility and necessity of nuclear energy as part of the energy mix and what that will mean for the environment.	The environmental case for why nuclear energy should be part of the energy mix has not yet been made. The Ministry of Economic Affairs and Climate Policy aims to do so now. This will help confirm the utility and necessity of nuclear energy projects such as the operating life extension, the construction of new nuclear power plants and the National Radioactive Waste Programme.
Draft bill for the Nuclear Energy Act	2024	This will comprise the amendment of the Nuclear Energy Act, incorporating the	The draft legislative amendment is currently being considered by the

Products at the level of national government	Year	Notes	Dependencies
		results of the operating life extension EIA and the Explanatory Memorandum.	Ministry of Infrastructure and Water Management and the Ministry of Economic Affairs and Climate Policy. The EIA and the Explanatory Memorandum are part of the legislative amendment. The Dutch Council of Ministers (in the event that no new cabinet has yet been formed) will then decide whether the draft can be presented for inspection.
Decision on the amendment of the Nuclear Energy Act by both Houses of Parliament	2025	Ultimately, the two Houses of Parliament (the Senate and the House of Representatives) will decide whether the legislative amendment passes. As soon as the legislative amendment has been passed, the operator of the nuclear power plant can apply for a (new) permit to extend operations of the plant.	After the draft legislative amendment has been presented for inspection, the responses received will be processed. This will be followed by a review by the Council of State. Only after this will the government decide on submitting the legislative proposal and will the Houses take a decision on the legislative amendment.
Preference decision on construction of two new nuclear power plants	2025	In parallel, work is ongoing on the second objective from the Rutte IV Coalition Agreement, the construction of two new nuclear power plants. It is expected that the Minister will be able to take a decision on the preferred location, including the plan EIA, in 2025.	The construction of two new nuclear power plants follows from the Rutte IV Coalition Agreement and is related to the NPE and the PEH. The procedure for the construction of the new plants assumes that the Borssele nuclear power plant will remain operational after 2033. Building two new nuclear power plants will also mean an increase in radioactive waste, which will be addressed in the NPRA (below). Added to that is the need highlighted by the TenneT system study to consider how two new nuclear power plants would be integrated into the high-voltage grid.
National Radioactive Waste Programme (NPRA)	2025	The Ministry of Infrastructure and Water Management is currently working on the NPRA that will come into effect in 2025. It draws up a new plan for how to handle our radioactive waste every ten years. The NPRA considers the handling of radioactive waste, i.e. the end of the nuclear fuel chain.	The NPRA has a direct relationship with operating life extension and the construction of new plants, because both involve the generation of more radioactive waste.

Products for the purpose of operating life extension by the operator	Year	Notes	Dependencies
10EVA (ten-yearly safety evaluation)	2023	Every ten years, the operator must demonstrate the safety of the nuclear power plant by means of safety studies. The results are presented to the ANVS for evaluation.	Independent procedure to assure the safety of the nuclear power plant.
SALTO missions (Safety Aspects of Long-Term Operation)	2022-2025	The International Atomic Energy Agency (IAEA) conducts missions for the purpose of ageing management of the nuclear power plant. The results will be included in the follow-up pathway.	Independent procedure to assure the safety of the nuclear power plant.
Technical studies	2022-2025	The operator of the Borssele nuclear power plant investigates which physical measures need to be taken in order to keep the nuclear power plant safely operational after 31 December 2033.	The performance of the technical studies is dependent on the decision by the Houses of Parliament on the legislative amendment and the results of the safety evaluations.
Permit application	2025-2029	In order to extend the operation of the plant, the operator must submit a new permit application to the ANVS. Aside from evidence concerning safety, the environmental impact assessment (EIA Phase 2) will be considered, including all relevant environmental studies such as the potential impact on Natura 2000.	The permit application is dependent on the legislative amendment and the results of the technical studies. Subsequently, in EIA Phase 2, it will need to be demonstrated that no significant detrimental environmental impacts will occur, or that these will in any event be mitigated.
Contracts	2025-2029	The operator draws up new contracts for the operating life extension. This includes contracts with fuel suppliers, but also contracts with COVRA and arrangements for the storage of radioactive waste in the future.	The contracts are dependent on the permit award by the ANVS, as well as on the options for storing the radioactive waste in a suitable manner (NPRA).
Other		**Notes**	**Dependencies**
Insight into the nuclear fuel chain and uranium mining (*see also Section 3.2 of this EIA for more information*)		Uranium mining takes place abroad. Nuclear power plants buy uranium from factories which are able to upgrade it into nuclear fuel from which energy can be obtained. Any environmental impacts from uranium mining must be monitored in the country where the mining takes place.	More uranium will be required if the Borssele nuclear power plant remains operational for longer, and if two new nuclear power plants are built.

As shown in the table above, there is a distinction between the, primarily strategic, choices for which the national government is responsible and the more on-site choices and considerations which are the purview of the operator of the nuclear power plant. It should be clear, however, that the two are interwoven. The operator of the nuclear power plant can effectively only submit an application for a permit for an operating life extension if there are no (statutory) restrictions or barriers at governmental level in response to the strategic choices made and if the legislative amendment has been implemented.

2.4 Legislation and the most important policy frameworks

This environmental impact assessment is the first element in the decision to delay the shutdown of the Borssele nuclear power plant. The key principles and prerequisites for the decision-making on the Borssele nuclear power plant follow from treaties, international agreements, laws and regulations and policy in areas including energy, spatial planning, the environment, the living environment, nature and safety.

Nuclear Energy Act

The Nuclear Energy Act is a framework act which relates to activities involving the use of ionising radiation or in the course of which such radiation is released. According to the Explanatory Memorandum, the purpose of the act is:

- To promote proper arrangements regarding the release and use of radioactive materials and of equipment emitting ionising radiation.
- Protection against the hazards associated with the use of radioactive materials and ionising radiation.

The scope of the act includes:

- Nuclear safety.
- Public health.
- Protection against the hazards of radioactive materials and ionising radiation in the workplace.
- Protection against detrimental consequences for the environment.

The Nuclear Energy Act comprises multiple permitting systems, all of which are relevant to the Borssele nuclear power plant. They relate to changing a facility (Section 15b), holding nuclear fuel (Section 15a), and holding, applying and disposing of radioactive materials (Section 29(1)). The above matters are addressed in more detail in the Nuclear Facilities, Fissionable Materials and Ores Decree ('the Decree') and the Decree on Basic Safety Standards for Radiation Protection.

Environment and Planning Act

The Environment and Planning Act has been on the Dutch statute book since 1 January 2024. The Environment and Planning Act brings together many rules relating to the human living environment. The aim of the Environment and Planning Act is to strike a good balance between utilising and protecting the physical living environment. The Water Act, the Nature Conservation Act, the Environmental Permitting (General Provisions) Act and the Environmental Management Act have been largely subsumed into the Environment and Planning Act. The Nuclear Energy Act has not been subsumed into the Environment and Planning Act. Insofar as the conventional environmental aspects of the Borssele nuclear power plant are not regulated by the Nuclear Energy Act, the Environment and Planning Act has become the most important statutory framework since 1 January 2024.

Borssele Nuclear Power Plant Covenant

In June 2006, the Minister of Economic Affairs, the State Secretary for Housing, Spatial Planning and the Environment, EPZ and the shareholders ERH (formerly Essent) and Delta Energy (formerly a public owned utility) signed a covenant relating to the Borssele nuclear power plant (Government Gazette 2006-136). The covenant is based on three important pillars:

- The Borssele nuclear power plant will remain operational until 2034 with very high safety standards. The Borssele nuclear power plant will, broadly speaking, continue to be among the 25 per cent safest nuclear power plants in the Western world.
- The owners ERH and Delta will invest a combined €250 million in renewable energy projects.
- No later than 31 December 2033, operation of the nuclear power plant will cease, immediately followed by decommissioning.

The EIA is not about the covenant but about the revision of the Nuclear Energy Act. A (new) covenant will follow at a later date if needed.

National Energy System Plan
The National Energy System Plan (NPE) describes how the Netherlands will develop an energy system appropriate to a climate-neutral society. The NPE sets out a long-term vision of the energy system in 2050, the route to getting there and the contributions required of the national government and other public authorities (such as municipalities). Every five years, the NPE is amended and updated where necessary in order to be able to take advantage of innovations and reflect developments in society. More information about the NPE and how you can get involved is available at Energy System 2050 (rvo.nl).

National Energy Network Programme
The draft National Energy Network Programme (PEH) was published in September 2023. The stimulus for developing the PEH is the Netherlands' commitment to achieving an energy transition. This objective requires a good energy infrastructure incorporating new, clean forms of energy. The PEH seeks to act in timely fashion to facilitate the national energy network, balancing this objective against other challenges and interests, within a national/international context and based on the precondition of a good quality living environment. The PEH takes the period from 2030 to 2050 as its time horizon and encompasses the entire territory of the Netherlands (with the exception of the North Sea).

The PEH replaces and updates SEV III, among other policy instruments, and offers a perspective on the energy system for 2030-2050 and the way in which this system can develop.

National Coordination Scheme
In the area around Borssele, and in particular the nearby docks, there are multiple energy projects in progress under the auspices of the national government, so-called National Coordination Scheme[19] projects. They include landfall sites for offshore wind projects, a high-voltage substation and various infrastructure projects. Taken together, these projects impose pressure on the region.

At the time of writing of the EIA Phase 1, the Ministry of Economic Affairs and Climate Policy is also working to increase the number of its stakeholder managers in the Borssele region. Exploratory discussions are also taking place between the project managers of the National Coordination Scheme projects (project procedure under the Environment and Planning Act) to establish how all the existing and future projects fit together. Subsection Section 2.5.2 describes the various projects in the region in more detail.

2.5 Reference situation

2.5.1 Reference situation of the Borssele nuclear power plant

The reference situation is a situation in the future in which autonomous developments are included, but without the intention. In this case, the intention is to extend the period of operation of the Borssele nuclear power plant. Simply put, this means that the reference situation – i.e. if the intention is not carried out – consists of a closed nuclear power plant plus legal and spatial planning developments in the vicinity of the plant. The reference year is therefore 2034. From that year (after 31 December 2033), no more energy may be released from the nuclear power plant in the absence of a legislative amendment.

Safety and decommissioning
If the nuclear power plant closes, that does not immediately mean it will no longer have any associated environmental impacts or (external) safety risks. Although the nuclear fuel still present will be removed and disposed of soon after the closure, the reactor vessel will still be radioactive. It will need a period of 2 to 3 years while it continues to emit radiation and cools down. During this period, it is essential that the emergency provisions of the nuclear power plant continue to work. Once radiation levels have fallen to safe levels and the reactor vessel has cooled down, the decommissioning period begins: this requires drawing up a decommissioning plan and applying for the required permits ahead of closure.

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[19] Until the entry into force of the Environment and Planning Act, the projects have been carried out under the National Coordination Scheme. The National Coordination Scheme allows for various decisions (permits and exemptions and a land use plan) required for a project to be taken simultaneously in consultation with regional governments. Following the entry into force of the Environment and Planning Act, these will become Project Decisions.

Airborne emissions
In the reference situation, airborne emissions from the nuclear power plant will be limited. As stated above, the emergency provisions of the nuclear power plant will initially still be important, and they will continue to be tested regularly. This means that the emergency power generators will still emit carbon dioxide to some extent. Transport for the employees still working at the now closed nuclear power plant will also result in some emissions. When the time comes to decommission the nuclear power plant, this work will also cause emissions due to the machinery required. Eventually, after decommissioning, there will be no more airborne emissions.

No discharge of cooling water
Immediately after the closure of the nuclear power plant, no more cooling water will be needed. This will also mean a reduction in the plume of heated water in the Western Scheldt. This will have an effect on habitat types that flourish in warmer water, but for the estuary of the Western Scheldt it means that the nuclear power plant will no longer have any form of impact on the water body and the species present.

Less radioactive waste
Subject to the removal of the remaining nuclear fuels from the nuclear power plant, the Borssele nuclear power plant will not produce any new waste. This will directly impact the quantity of radioactive waste that is produced, recycled and stored in the adjacent COVRA facility.

Changing energy mix
The Borssele nuclear power plant generates approximately 485 MW per year. At present, that represents 3% of the energy mix. As soon as the nuclear power plant stops generating energy, it will therefore be necessary for 3% of the Netherlands' energy mix to be generated in a different way. The precise associated environmental impacts may diverge significantly, depending on the type of energy source used to make up those 3%. Possible examples are visual intrusion caused by new wind turbines, space taken up by solar panels or external safety risks from hydrogen applications.

2.5.2 Reference situation of the area around Borssele nuclear power plant

Alongside the Borssele nuclear power plant itself, there will also be developments in the surrounding area up to the reference year 2034. These projects in the surrounding area are depicted in Figure 2-2. The current status (February 2024) is explained in more detail beneath the figure:

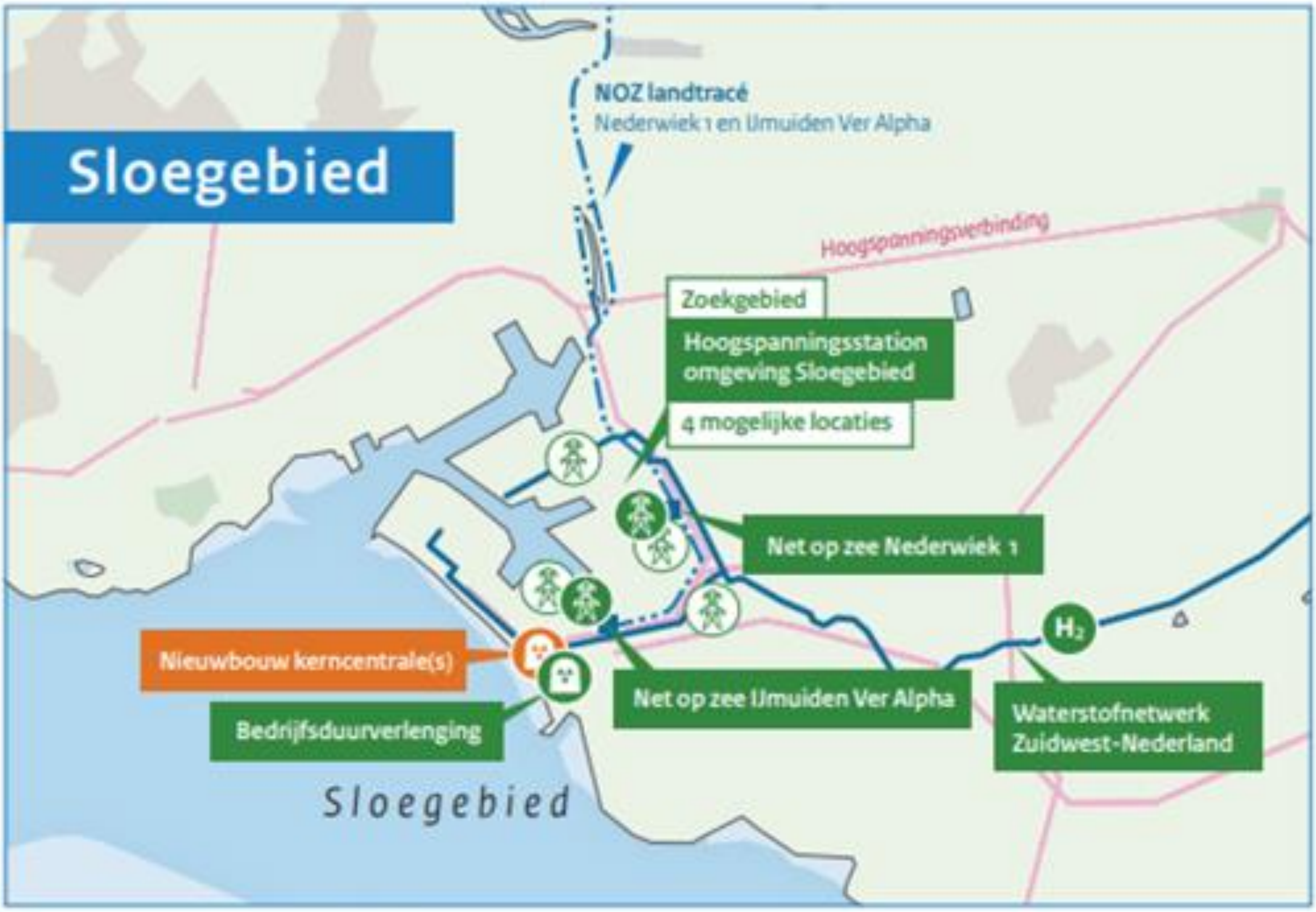

Figure 2-2 Projects in the Sloegebied area. Source: Response memorandum to statements of views on Memorandum on Scope and Level of Detail

Offshore grid: IJmuiden Ver Alpha
TenneT is constructing an underground high-voltage connection from the IJmuiden Ver wind farm zone to the national high-voltage grid at Borssele. The IJmuiden Ver Alpha offshore grid project will connect an additional 2 gigawatts (GW). The wind turbines in the IJmuiden Ver wind farm zone will be directly connected to a platform in the wind farm zone. The platform will be connected to a converter station on land by means of underground 525 kilovolt (kV) direct current cables. That converter station will transform the direct current into alternating current. The electricity will then be conveyed from the converter station to the Borssele high-voltage substation by means of alternating current cables.

Offshore grid: Nederwiek 1
TenneT is constructing an underground high-voltage connection from the Nederwiek 1 offshore grid wind farm zone to the national high-voltage grid at Borssele. This is one of three underground links that will connect the Nederwiek wind farm zone to the national high-voltage grid. The Nederwiek 1 offshore grid project will connect an additional 2 gigawatts (GW). The wind turbines in the Nederwiek wind farm zone will be directly connected to a platform in the wind farm zone. The platform will be connected to a new converter station in Borssele by means of underground 525 kilovolt (kV) direct current cables.

Southwest Netherlands Hydrogen Network
Hydrogen has the potential to play a major role in the renewable energy system. Possible uses of hydrogen in industry include a replacement for natural gas to reduce CO_2 emissions. In order to facilitate this, a national network is being built to transport hydrogen. The Southwest Netherlands Hydrogen Network is part of the national hydrogen network being built by Hynetwork Services (a wholly-owned subsidiary of Gasunie). The national hydrogen network links together five industry clusters in the Netherlands, hydrogen storage facilities and neighbouring countries. The Southwest Netherlands Hydrogen Network extends from the Belgian border at Sas van Gent to Vlissingen in Zeeland and Moerdijk in Noord-Brabant.

High-voltage substation in the Sloegebied area
TenneT is working to build a new 380kV high-voltage substation in the Sloegebied area. Once the IJmuiden Ver Alpha offshore grid project comes online, the existing 380 kV high-voltage substation in Borssele will not have any capacity left to connect new transmission lines. New connection capacity will be needed for future initiatives, such as hydrogen production, as well as for the 'Nederwiek 1 offshore grid' project. This is why a new 380 kV high-voltage station is necessary in or around the Sloegebied seaport and industrial area.

Construction of new nuclear power stations
With a view to the attainment of climate objectives and the goal of an affordable, reliable, safe, sustainable and equitable energy system, the government is taking the initiative to construct two new nuclear power plants. The Letter to Parliament of 9 December 2022 explained which preparations the government is making and describes a number of initial choices based on exploratory studies. This letter also designates the Borssele reserved area as the preferred location.This has been done in order to be able to conduct as many preparatory studies as possible in parallel.

The first step is to prepare a Preference Decision. In order to arrive at a Preference Decision, several steps are being taken by the Ministry of Economic Affairs and Climate Policy: multiple feasibility studies are being conducted, a plan EIA is being carried out and an Integrated Impact Analysis is being drawn up. The aim is for the government to be able to take a Preference Decision in 2025 and in doing so designate a plot where the two new nuclear power plants can be built. By means of a project decision, the government can secure authorisation to implement, have in operation or maintain a "project".

The first step in this procedure is the start of the EIA procedure. On 23 February 2024, the so-called Notification of Intention and Proposal for Participation was published, and it remained available for inspection until 4 April 2024. All interested parties were given the opportunity to respond to this document, with the goal of mobilising as many residents, organisations and other (international) stakeholders to give their views on the intention.

3 Background on the Borssele nuclear power plant and nuclear energy

At the request of the EIA Committee, chapter 3 contains information about the general operation of the Borssele nuclear power plant (Section 3.1). In addition, Section 3.2 describes the general nuclear fuel chains which apply to the Borssele nuclear power plant. Finally, Section 3.3 contains a life cycle analysis of a nuclear power plant and compares the CO_2 emissions from electricity generation by means of nuclear energy with CO_2 emissions from electricity generation using other energy sources. This chapter goes beyond what is required for the legislative amendment but is included for the sake of completeness.

3.1 General description of the Borssele nuclear power plant

The Borssele nuclear power plant is located approximately 1.4 kilometres north-west of the village of Borssele, in the province of Zeeland – see Figure 3-1. The plant is located directly behind the sea dike on the site of N.V. Elektriciteits Productiemaatschappij Zuid-Nederland (EPZ). EPZ is jointly owned by ZEH Energy B.V. and Energy Resources Holding BV, which in turn is part of the German energy company RWE. EPZ operates the nuclear power plant, which has been operational since 1973.

Figure 3-1 Location of the Borssele nuclear power plant. Source: EPZ

The Borssele nuclear power plant is a pressurised water reactor with a thermal power output of approximately 1366 MW and a net electrical power output of 485 MW. The existing nuclear power plant generates around 3.8 terawatt hours (TWh) of electricity per year, representing slightly more than 3% of total electricity generation in the Netherlands in 2021[20].

The so-called pressurised water reactor is the most common type of nuclear reactor still used for new nuclear power plants. In a reactor of this type, water under high pressure is used to transfer the heat generated during nuclear fission. That heat is ultimately used to produce electricity. The same water is also used to moderate the neutrons, which is necessary in order to keep the nuclear fission process going. The energy production in the reactor is the result of splitting heavy atomic nuclei, namely uranium and plutonium nuclei. Each of these substances consists of a mixture of isotopes.

The plant consists of a reactor with a reactor cooling system (the primary system), a conventional section (the secondary system), which provides for the generation of electricity and the transfer of the heat, and the necessary auxiliary and secondary nuclear installations. Table 3-1 describes certain characteristics of the Borssele nuclear power plant.

Table 3-1 Characteristic details of the Borssele nuclear power plant[21]

Net electrical capacity	**488 MW_e**
Gross thermal power of the reactor	1366 MW_{th}
Net yield	36%
Primary system	
System pressure	155 bar
Average temperature	305 °C
Secondary system	
Steam pressure	57 bar
Steam temperature	270 °C

Figure 3-2 shows a schematic drawing of the plant. At the heart of the nuclear power plant, safely protected by steel and concrete, is the core. Within the core (1) of the reactor, which is housed in the reactor vessel (2), a controlled chain reaction is maintained, with heat being produced through the splitting of uranium or plutonium nuclei. This heat is transferred to the coolant, which consists of water to which boron has been added. This coolant is pumped around in a circular loop, the primary loop. The coolant is pressurised to such a point that it does not boil when it absorbs the heat produced. The coolant transfers the heat to the second (secondary) loop. Any radioactivity remains in the primary loop and is not transferred to the secondary loop.

The heat transfer takes place in two steam generators (3), where the water from the secondary loop is converted into steam. After the reactor has been shut down, causing the fission process to stop, the core continues to produce heat for some time, due to the presence of radioactive fission products with a short half-life. This heat (decay heat), which amounts to several per cent of the reactor's power at full capacity, therefore still needs to be transferred after the reactor has been shut down.

The steam produced in the steam generators drives a steam turbine (4), which in turn drives an electricity generator (dynamo) (5), which produces the electricity. The exhaust steam from the turbine condenses into water in three condensers (6), which are cooled using water from the Western Scheldt (7). The primary loop includes a pressuriser which regulates the pressure in the cycle by means of water spraying or electrical heating. The pressuriser has safety valves which are opened in the event of excessive pressure in the primary loop.

[20] More electricity from renewable sources, less from fossil sources (cbs.nl)

[21] In accordance with Veiligheidsrapport Kernenergiecentrale Borssele | Publicatie | Autoriteit NVS, November 2015

When the fuel elements have been largely used up, they are removed from the core after the reactor has been shut down and placed in a fuel storage basin which has its own cooling system. After the used fuel elements have been stored underwater in the fuel storage basin for several years, during which time the level of radioactivity diminishes, the heat production will have reduced to such an extent that the elements can be safely transferred from the nuclear power plant to the reprocessing plant in a special transport container.

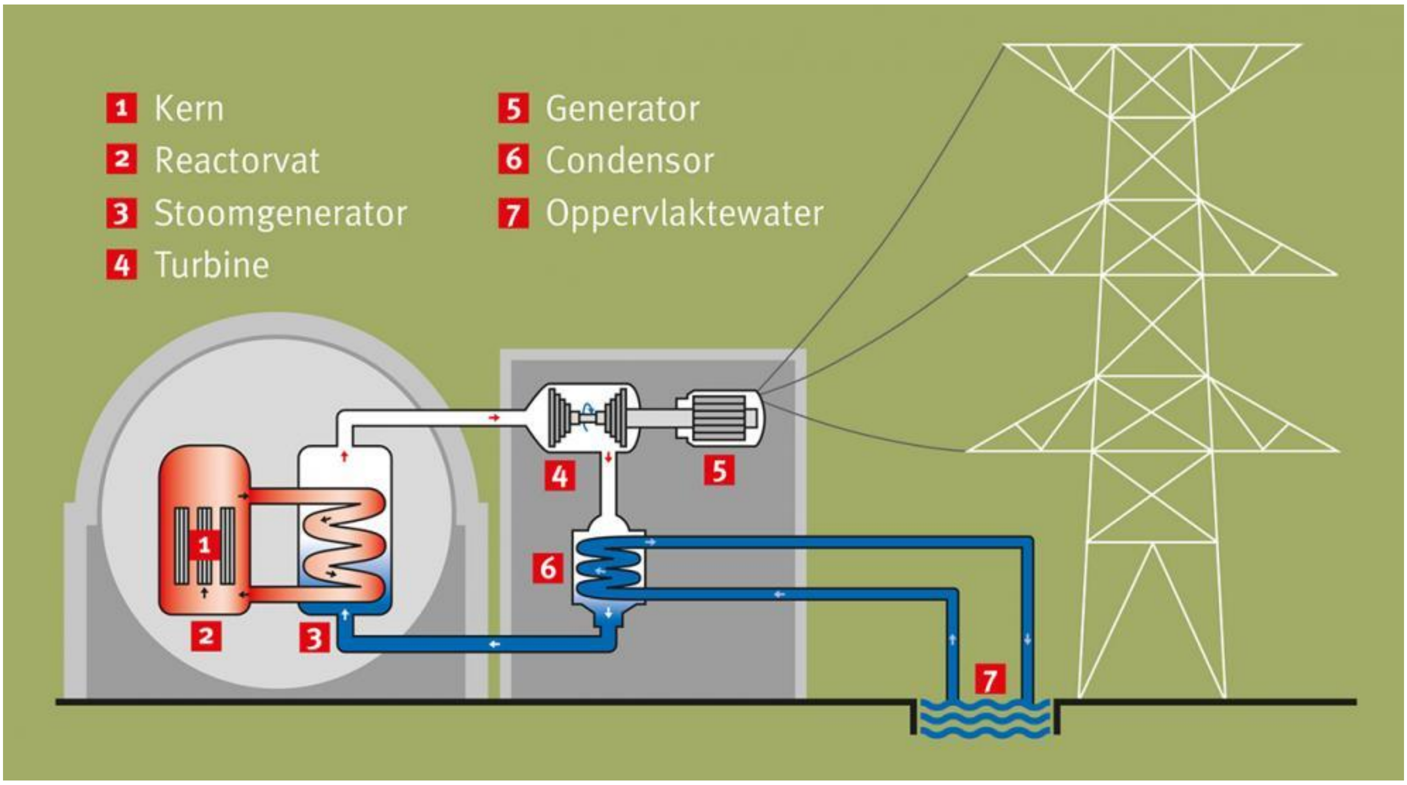

Figure 3-2 Schematic representation of nuclear power plant. Source: EPZ

3.1.1 Safety barriers

The Borssele nuclear power plant has five safety barriers that protect people and the environment against radiation and radioactive substances. The entire design is based on keeping radioactivity inside the safety barriers under all process conditions. The different barriers are indicated with numbers in Figure 3-3.

Barrier 1: Nuclear fuel tablet
The nuclear fuel tablet, in the form of sintered porcelain, is the first barrier. Approximately 90 per cent of the radioactivity comes from solids that remain enclosed in the nuclear fuel tablet. Only gaseous and volatile radioactive substances (inert gases, iodine, caesium) can escape from the nuclear fuel tablet.

Barrier 2: Fuel rod
The nuclear fuel tablets are stacked in a hermetically sealed tube made of zirconium (which is impermeable to gas and liquids). The fuel rod holds the gaseous and volatile radioactive substances within it. A bundle of 205 fuel rods together make up a nuclear fuel element, of which the reactor contains 121.

Barrier 3: Primary system
The core is enclosed in the primary system. The primary loop is a closed loop in which coolant (conditioned water) is pumped around. This water is heated to a maximum temperature of 320°C and maintained at a pressure of 155 bar so that it does not boil. Hence the name ‘pressurised water reactor’. The primary loop (reactor vessel, main coolant pumps, steam generators and pipes) consists of highly overdimensioned (centimetres thick) steel components of the highest quality. Radioactive substances cannot escape from it. The primary loop is contained in bunkered spaces. The concrete provides radiation protection during operation, as well as protection of the installation against threats from inside and outside.

Barrier 4: Containment
The primary loop is enclosed in a steel sphere that is centimetres thick. This ensures that if the earlier barriers fail, the radioactivity cannot escape outside the installation. The sphere is a strong airtight structure and can withstand internal gas and steam explosions, thus averting emissions from the primary loop in the event of an accident.

Barrier 5: Reactor building
The nuclear systems are enclosed in the reactor building, recognisable from the outside by the characteristic concrete dome. The building represents the final physical barrier between the radioactive substances in the core and the environment. Conversely, the concrete building is the first barrier to threats from outside reaching the core.

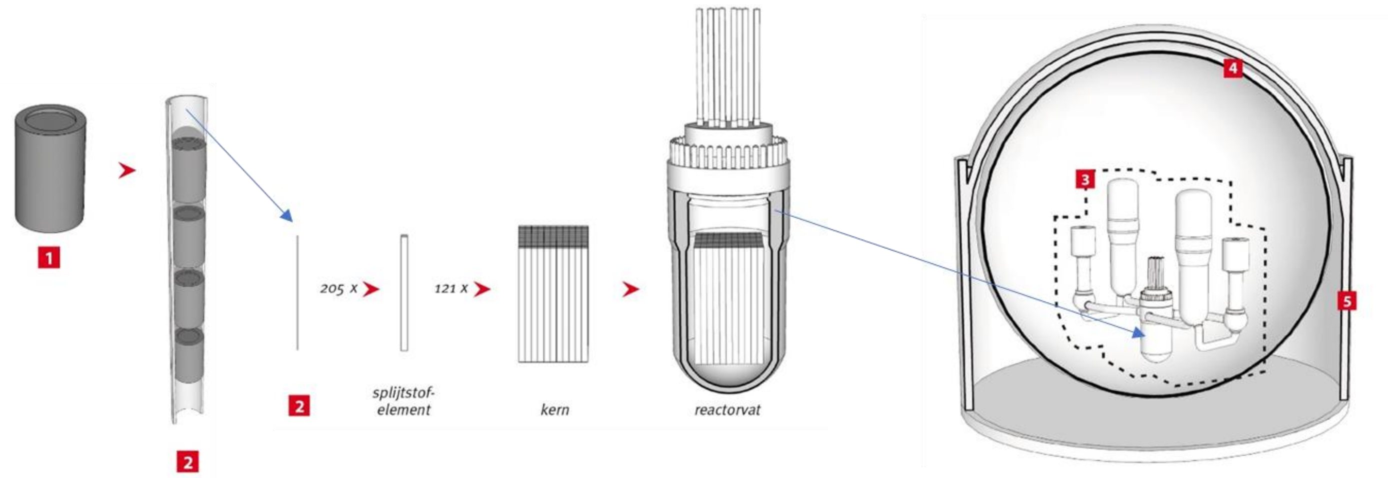

Figure 3-3 Safety barriers at the Borssele nuclear power plant. Source: EPZ

Following the accident at Chernobyl in 1986, the safety culture and the control of the process came under intense scrutiny. The 2011 earthquake and tsunami which had a major impact on the Fukushima nuclear power plant led to a new focus on potential situations of an inconceivably catastrophic scale. Scenarios now take account of the complete destruction of the Netherlands' infrastructure and dislocation of society such that help from outside would be extremely difficult. Numerous improvements and assurances have been implemented, for example:

- A new 380 kV connection to the national power grid has been constructed.
- Extra cooling capacity has been added for the fuel storage system.
- An external cooling system has been provided for the reactor vessel, which involves flooding the cavity between the reactor vessel and the concrete enclosure with water. External reactor vessel cooling can be necessary in extreme situations to ensure that a melting core remains contained within the reactor vessel.
- Additional equipment such as mobile pumps and emergency power generators have been purchased which can be connected at various points in the nuclear power plant.
- By establishing larger, distributed stocks of diesel and water which are accessible in different ways, the length of time the plant can make do without outside help has been extended to more than 14 days.

3.1.2 Cooling

Whether the plant is operational or is shut down for maintenance, the nuclear fuel in a pressurised water reactor must always remain submerged. This is necessary in order to transfer the (decay) heat which the radioactive fission products generated by nuclear fission continue to produce for a long time and to protect against the resulting radiation. There are multiple independent systems and water reserves to ensure that the core remains covered with water under all circumstances. In addition, there are systems that ensure that the heat from the core can be transferred under all circumstances. These systems supplement one other or take over from one another.

The nuclear power plant has two main coolant pumps. During operation, these pumps cause coolant to circulate through the primary system; if both pumps fail, the reactor is automatically switched off and a process of natural circulation starts up with sufficient capacity to transfer the decay heat.

When the plant is producing electricity, the water/steam loop is cooled using water from the Western Scheldt, pumped up into the cooling water intake building. Cooling takes place in the condensers, within which the water from the Western Scheldt causes steam to condense back into water, after which it is conveyed to the steam generators in the water/steam loop. This cooling circuit is required for electricity production, and is therefore not a safety system.

When the power plant is not in operation, the core still needs to be cooled in order to discharge residual heat. The chain reaction has stopped, but due to the radioactive decay of the fission products, the core is still producing heat. The main coolant transfers this heat to the interim cooling system, which is cooled using water from the Western Scheldt in three heat exchangers. This cooling chain is duplicated and transfers the decay heat from the reactor to the Western Scheldt in normal and failure conditions. These systems therefore ensure that heat from the core can be discharged if that is no longer possible via the water/steam loop. For the unlikely event that water from the Western Scheldt should not be available, a backup system was installed in 1997 that makes use of eight boreholes to the saline groundwater. With the help of powerful underground pumps, saline groundwater can be pumped up in order to transfer the decay heat from the primary loop, via an interim cooling system.

3.2 Nuclear fuel chain

This section describes the nuclear fuel chain for the Borssele nuclear power plant. This description is followed by an indication of which parts of the chain are considered in this EIA Phase 1 and which parts are not.

The nuclear fuel chain comprises the industrial processes by means of which new nuclear fuel is produced, the use of nuclear fuel in the nuclear reactor, the processes by means of which the used nuclear fuel is removed from the nuclear power plant, the recycling, if applicable, of the uranium and plutonium, and finally the management of the radioactive residues.

3.2.1 Uranium stocks

Uranium is the energy source used to generate nuclear energy. Pure uranium is a silvery white, radioactive metal which is malleable and deformable and has a very high density (18.96 kg per litre, which is 65% more dense than lead). Pure uranium remains in solid form up to a temperature of approximately 1400 K (1127 ℃) and its boiling point is approximately 4400 K (4127 ℃). Isotopes are atoms of the same chemical element, which therefore have the same number of protons, but in which the number of neutrons varies. The two most important uranium isotopes that occur on earth are uranium-238 (99.3%) and uranium-235 (0.7%). For nuclear energy, uranium which has been enriched into uranium-235 is used because this isotope is fissionable by thermal neutrons. The Borssele nuclear power plant uses uranium enriched to 4.4% uranium-235. Uranium-238 is also important in the reactor, because it can be transmuted through neutron radiation to plutonium-239, which can also serve as a nuclear fuel.

Uranium does not occur in nature as a pure element, but only chemically bonded in uranium ores. The most commonly used uranium mineral for the extraction of uranium is so-called uraninite, which consists primarily of uranium dioxide (UO_2). Uranium ores occur distributed across the earth, but with great variations in uranium content and extractability. Approximately half the proven global primary uranium reserves are found in Australia, Kazakhstan and Canada. Certain ore deposits in Canada have a very high percentage of U, up to 10%. However, most other deposits contain much lower-grade ores.

Alongside the uranium ore reserves present in nature, a significant proportion (over 20%) of the available uranium reserves consist of secondary uranium, in the form of used nuclear fuel from nuclear power plants, military stocks and depleted uranium. Alongside the proven primary and secondary uranium reserves, unproven reserves of uranium in the form of extractable ores are estimated at a total of approximately 35 million tons of uranium.

3.2.2 Closed fuel cycle

In the 1970s, a closed fuel cycle was chosen for the Dutch nuclear power plants (the existing Borssele plant and the decommissioned Dodewaard plant[22]). This means that after use in the nuclear power plant, the materials uranium and plutonium are reprocessed into new nuclear fuel. Figure 3-4 shows a simplified representation of the closed fuel cycle. This cycle is explained in more detail in the text below. The numbers of the headings refer to the numbers in Figure 3-4.

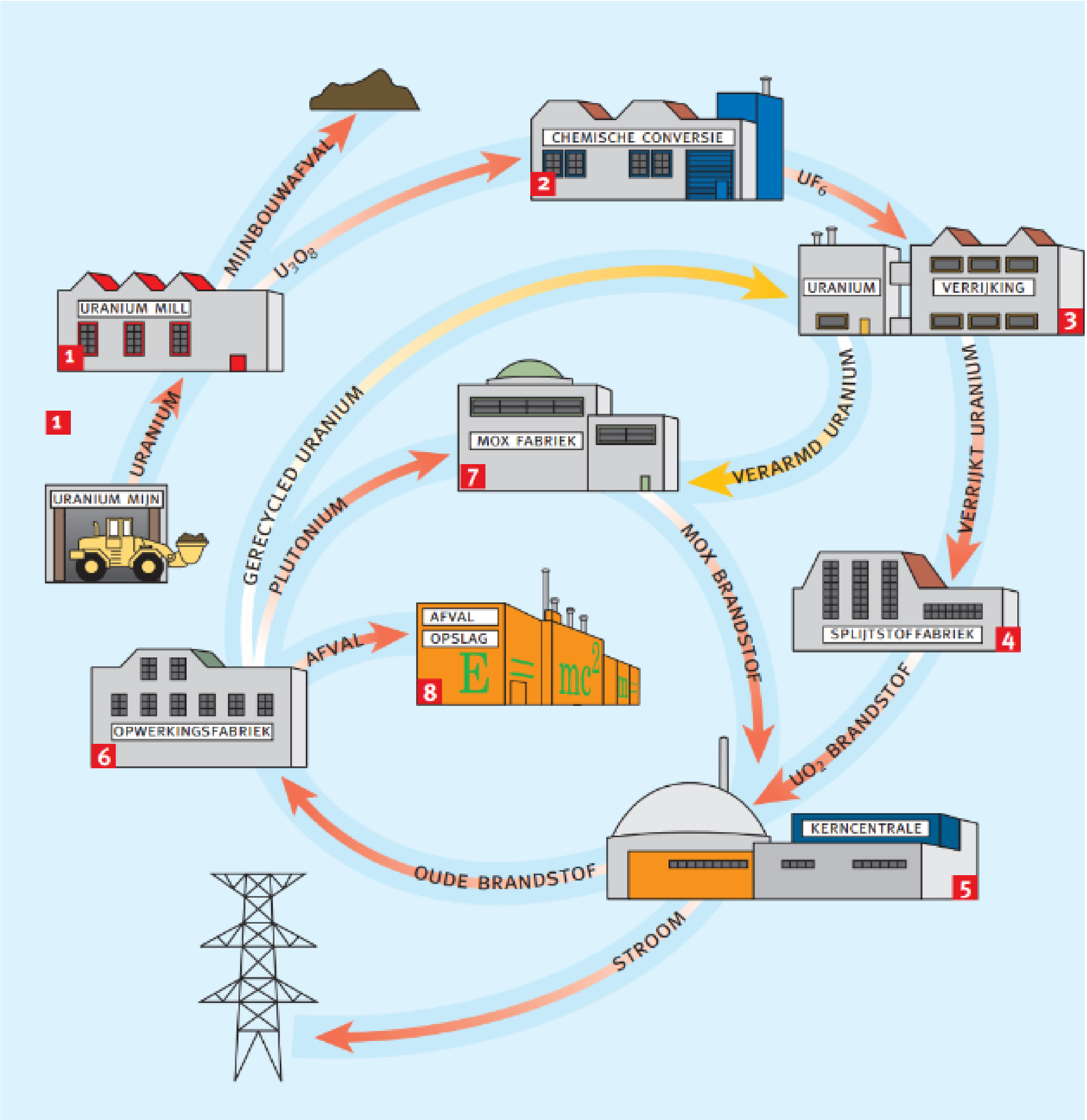

Figure 3-4 Simplified representation of the closed fuel cycle. Source: EPZ, Fuel Diversification EIA (July 2010)

[22] The Dodewaard nuclear power plant, managed by Gemeenschappelijke Kernenergiecentrale Nederland (GKN), became the first Dutch nuclear power plant in 1969. Electricity production ceased in 1997.

1. Ore mining
The nuclear fuel cycle begins with the mining of uranium ore and its purification into U_3O_8, a chemical product that is traded as '*yellowcake*' or '*uranium concentrate*'. This product is a stable, grainy, yellow coloured substance that is usually traded in 200 litre steel drums. Generally speaking, three methods are used for ore extraction: underground mining, open-cast mining and in-situ leaching. Briefly put, underground mining is primarily used for deeper lying, richer ore deposits (deposits with a high uranium content of approximately 1% or more), open-cast mining for lower-grade ore deposits located closer to the surface, and solution mining for lower-grade or smaller, deeper lying ore deposits in porous rock.

When mining uranium by means of open-cast or underground mining, ore which is 'rich' in uranium is dug out and separated from the source rock. Ore containing uranium is mined below ground or above ground and milled into a powder in ore mills, after which the uranium is extracted from it by means of a chemical process. The remaining pulverised source rock (the so-called 'tailings') is carefully managed as mining waste, because it still contains natural radioactive substances.

In the case of in-situ leaching, a number of holes are bored to the rock stratum where the uranium is located. The technique takes advantage of the fact that some rock strata containing uranium deposits are porous. By injecting water with a solvent added to it into the boreholes, a solution containing uranium can be pumped back up without the need to mine the ore itself. In-situ leaching, which is used on a large scale in Kazakhstan, for instance, results in relatively little waste and enables even low-grade ores with a low uranium content to be exploited in an economic manner.

According to the World Nuclear Association[23], in 2022, approximately 49,000 tons of uranium were produced from mining worldwide. In that year, Kazakhstan produced the largest proportion of uranium from mines (43% of worldwide stocks), followed by Canada (15%) and Namibia (11%). Uranium production varies from year to year, depending on factors such as market demand, prices and mining activity. The primary production from mines is supplemented by secondary stocks, formerly mainly from ex-military material, but now also from recycling and from stocks built up in times of reduced demand.

2. Chemical conversion
Natural uranium always contains 0.7% uranium-235 (fissionable uranium). For the efficient commercial operation of a nuclear power plant, this concentration must be increased through enrichment. In order to enrich uranium, it first needs to be converted into gaseous form. To this end, the U_3O_8 is converted into uranium hexafluoride (UF_6) in a number of chemical process steps. Uranium hexafluoride is the only known compound of uranium that is relatively easy to turn into a gaseous form at ambient temperatures. The process takes place in so-called conversion plants.

3. Uranium enrichment
Uranium enrichment takes place by means of physical processes that utilise the minimal difference in mass between UF_6 molecules that contain the heavier uranium-238 and those that contain the lighter (fissionable) uranium-235. Older enrichment plants use the gas diffusion process, which is highly energy intensive. Virtually all newer installations are based on the more efficient ultracentrifuge technology. The UF_6 gas is treated in rapidly rotating cylinders, causing heavier isotopes to be pushed towards the cylinder walls. The enriched uranium is transported to the factory for nuclear fuel manufacture.

4. Production of nuclear fuel elements
In the factory where the nuclear fuel is manufactured, the fluorine is stripped from the uranium, with the UF_6 being converted into uranium dioxide, UO_2. The uranium dioxide (a grey powder) is pressed into tablets and baked in ovens to form a ceramic substance ('sintered'). These ceramic tablets ('pellets') are the building blocks of the nuclear fuel element. A stack of these tablets several metres long is enclosed in a tube made of a special alloy, Zircaloy[24]. The tube is welded closed to form a fuel rod; for the Borssele nuclear power plant, 205 fuel rods are bundled together to create a nuclear fuel element.

[23] Uranium Production | Uranium Output - World Nuclear Association (world-nuclear.org)
[24] Alloy containing the element zirconium.

5. Uranium fission in the nuclear power plant
Each year, a nuclear power plant needs a number of nuclear fuel elements in order to replace exhausted elements which have been supplying energy for a number of years. The exhausted elements are usually called 'used' nuclear fuel elements. Used nuclear fuel elements still contain approximately 94% of the original weight of uranium, with a residual enrichment of 0.6 to 0.8 weight percentage uranium-235, comparable to naturally occurring uranium. They also contain approximately 1% of plutonium, and the rest is made up of radioactive fission products and actinides (radioactive heavy metals such as americium).Some of the radioactive fission products have a short half-life and produce a significant quantity of heat after being removed from the reactor. After the used fuel elements have been stored underwater in the fuel storage basin for at least approximately two years, heat production has reduced to such an extent that the elements can be safely transferred from the nuclear power plant to the reprocessing plant in a special transport container. They are then recycled in the reprocessing plant.

6. Fuel element reprocessing
There are various installations around the world for reprocessing nuclear fissile materials, primarily in France, the United Kingdom, Russia, India and Japan. EPZ has had a commercial relationship with the Orano plant in La Hague (France) since 1976. The nuclear fuel elements are transported from the Netherlands to France in specially designed transport containers. In the reprocessing plant, the nuclear fuel elements are cut into pieces so that the tablets are accessible in order to be leached out using an acid solution. The uranium and the plutonium are then separated in a number of chemical process steps.

7. Recycling
RepU[25] stands for reprocessed uranium. In a facility in Pierrelatte (France), the uranium produced by the reprocessing plant in La Hague is converted into uranium hexafluoride (UF_6) or uranium oxide (U_3O_8), depending on which manner of reuse is chosen.

In contrast to RepU, the plutonium recovered in the reprocessing plant in La Hague is not physically returned to customers by Orano. For reasons of security, the plutonium is securely stored in La Hague awaiting actual reuse. When a batch of plutonium is needed for the production of mixed oxide (MOX), it is taken from the vault at La Hague to the MELOX plant in southern France. For this purpose, special high-security transports are carried out by road.

Mixed oxide is produced by mixing plutonium oxide (PuO_2) with depleted uranium oxide (UO_2). The mixed oxide is pressed into tablets which are baked ('sintered') in a process that is otherwise analogous to the manufacture of nuclear fuel from enriched uranium.

8. Radioactive waste
When recycling used fuel elements, along with the usable uranium and plutonium, unusable radioactive waste is left over. This falls into two categories:

[R 1] Highly radioactive nuclear fission products, which made up 4-5% of the original weight. These are vitrified, so that the radioactive substances cannot escape (leach out) and packed into standard 180 litre canisters. As a result of the high concentration of radioactive substances, these canisters initially still produce heat, approximately 1 kW each. For this reason, for the first few years they need to be cooled.

[R 2] Waste containing less than 0.1% of the total radioactive substances, consisting of the metal parts of the nuclear fuel elements. These fragments of the top and bottom end plugs of empty fuel rods, for example, are compacted under high pressure and likewise packed into standard 180 litres canisters. This category of waste is known as 'compacted residue'. These packagings do not require cooling.

Every year, the recycling of the nuclear fuels used in the Borssele nuclear power plant results in approximately 8.5 canisters of vitrified nuclear fission waste and approximately 8 canisters of compacted residues, making up a total waste volume of less than 3 m^3 per year.

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[25] Abbreviation of: Reprocessed Uranium.

Storage of radioactive waste
COVRA is the organisation charged by the Dutch government with the management of radioactive waste(s). The low and medium-level radioactive waste generated by the operation of the Borssele nuclear power plant is directly presented to COVRA. The reception and storage of the canisters containing nuclear fission waste and compacted residues takes place in a special building, the High-level Radioactive Waste Treatment and Storage Building (HABOG). This facility has a section in which the heat-producing vitrified waste is stored, which is cooled by means of natural convection of air. In another part of the building, non-heat producing canisters (compacted residues) are stored. Both types of canister are designed with a view to long-term storage; they consist of durable materials such as stainless steel and glass. The storage of waste in HABOG may be described as inherently safe, which is to say that no human intervention is required.

COVRA has been tasked by the Dutch government with storing the waste above ground for at least 100 years. Over those 100 years, the activity of the waste and therefore also the heat production will decline as a result of radioactive decay. This significantly simplifies the future handling of the waste, with a view to final disposal. The policy of the Dutch government is that the final disposal of radioactive waste deep underground must be designed to allow for recovery of the waste. This requirement only applies to the period in which the final disposal facility remains open. A provision has been created for the construction of a final disposal facility, filled from contributions by the suppliers of high level radioactive waste.

3.3 CO_2 emissions across the chain

3.3.1 Life-cycle

A nuclear power plant is not a self-contained system. It is only the most visible element of the nuclear energy chain and is at the heart of a series of industrial processes. This is shown in diagrammatic form in Figure 3-5. The life-cycle of a nuclear power plant may be divided into three categories:

a. Processes that take place one time before contemporary (i.e. operational) processes and comprise the construction of the facility (in this case the Borssele nuclear power plant) and the supply of materials.
b. Operational processes that take place during the operation of the nuclear power plant and result in greenhouse gases which are continually emitted per unit of generated electricity. These comprise uranium mining, milling, conversion and enrichment, the manufacture of fuel rods, transport, operation and maintenance of the facility, and reprocessing. The restoration of uranium mines is also included as an operational phase process because the need for mine restoration is regulated by the demand for uranium for electricity generation.
c. Future processes that need to be performed following the final closure of the nuclear power plant. These processes take place one time after the operational processes of facility have ceased and comprise the decommissioning of the facility, the removal/recycling of non-radioactive waste and the temporary, long-term and permanent storage of radioactive waste after electricity generation and the facility's lifetime have come to an end.

In each process in the nuclear chain, materials and energy are used and CO_2 and other greenhouse gases may be emitted. No CO_2 emissions take place during uranium fission in the nuclear power plant.

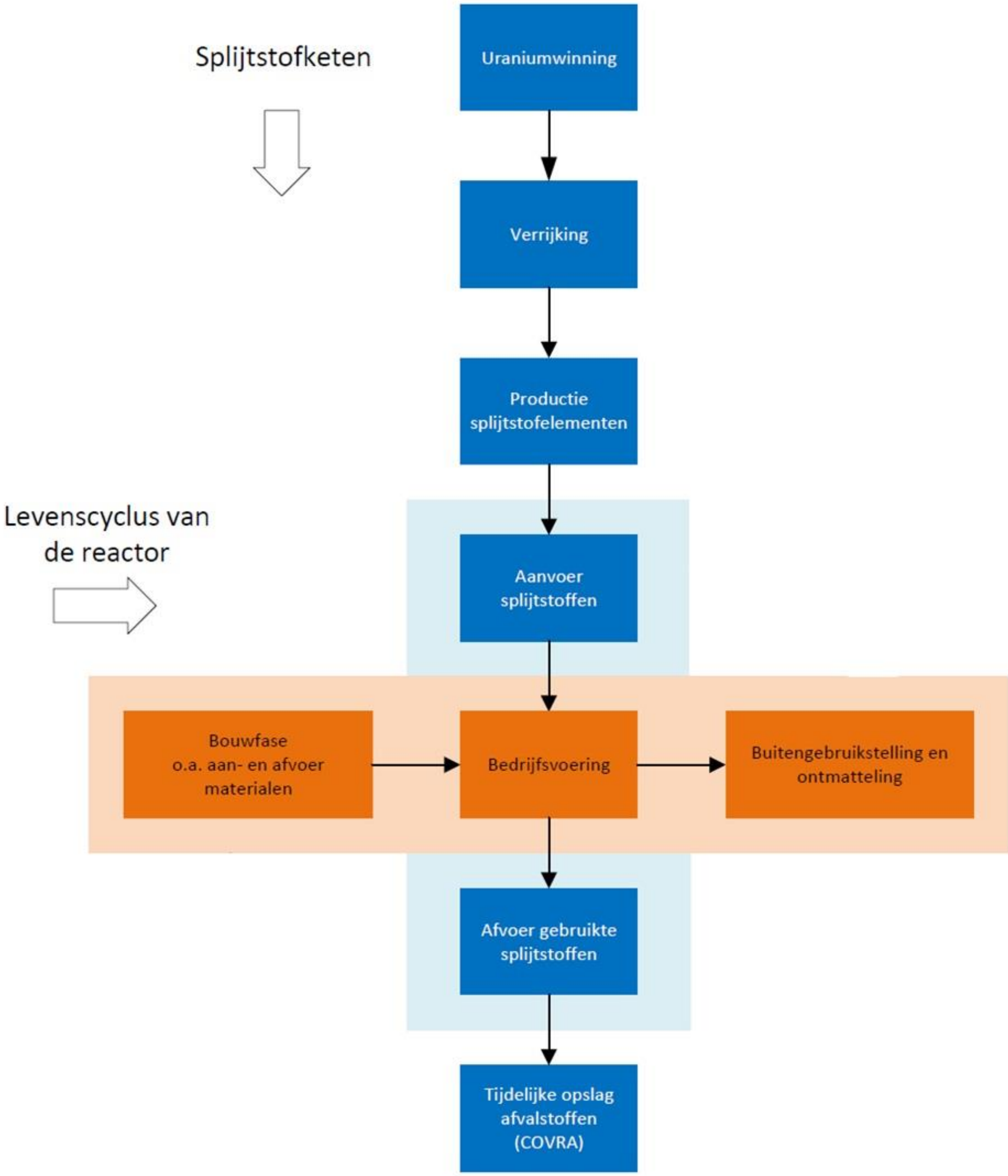

Figure 3-5 Nuclear fuel chain and life-cycle of a nuclear reactor

3.3.2 Nuclear energy in comparison with other energy sources

Mining and enriching uranium is a CO_2 intensive process that takes place repeatedly. However, total CO_2 emissions are (relatively) low in relation to the amount of electricity that can be generated from uranium. They are comparable to emissions from the production of steel that is required for the construction of wind turbines. The production of steel is also a CO_2 intensive process. Nevertheless, the quantity of CO_2 released in the production of steel for a wind turbine is small in comparison with the total electricity production over the lifetime of the wind turbine.

Nuclear energy also offers a number of other benefits. The area of land used during the life-cycle of nuclear energy is minimal. The high energy density of fuel elements and the small footprint of nuclear power plants results in a high energy production per square metre. The impact on human health and biodiversity is also generally low for pressurised water reactors.[26]

On the other hand, CO_2 emissions from the extraction and enrichment of uranium are highly dependent on the energy sources used in those processes. For example, large quantities of electricity are used in the enrichment of uranium. If the electricity production in the country where the enrichment takes place comes largely from renewable sources and/or nuclear energy, the (indirect) CO_2 emissions from the enrichment will be reduced. Aside from that, the regular operation of a nuclear power plant (including the Borssele nuclear power plant), requires large quantities of water.

The graphic below in Figure 3-6 is taken from the publication Renewable Energy Sources and Climate Change Mitigation issued by the IPCC (Intergovernmental Panel on Climate Change) in 2011 and shows the total greenhouse gas emissions over the life-cycle of different renewable and non-renewable energy sources. It was based on tens of studies on the emissions of greenhouse gases over the entire life-cycle of electricity production.

[26] Carbon Neutrality in the UNECE Region: Integrated Life-cycle Assessment of Electricity Sources, UNECE, 2021. LCA_3_FINAL March 2022.pdf (unece.org)

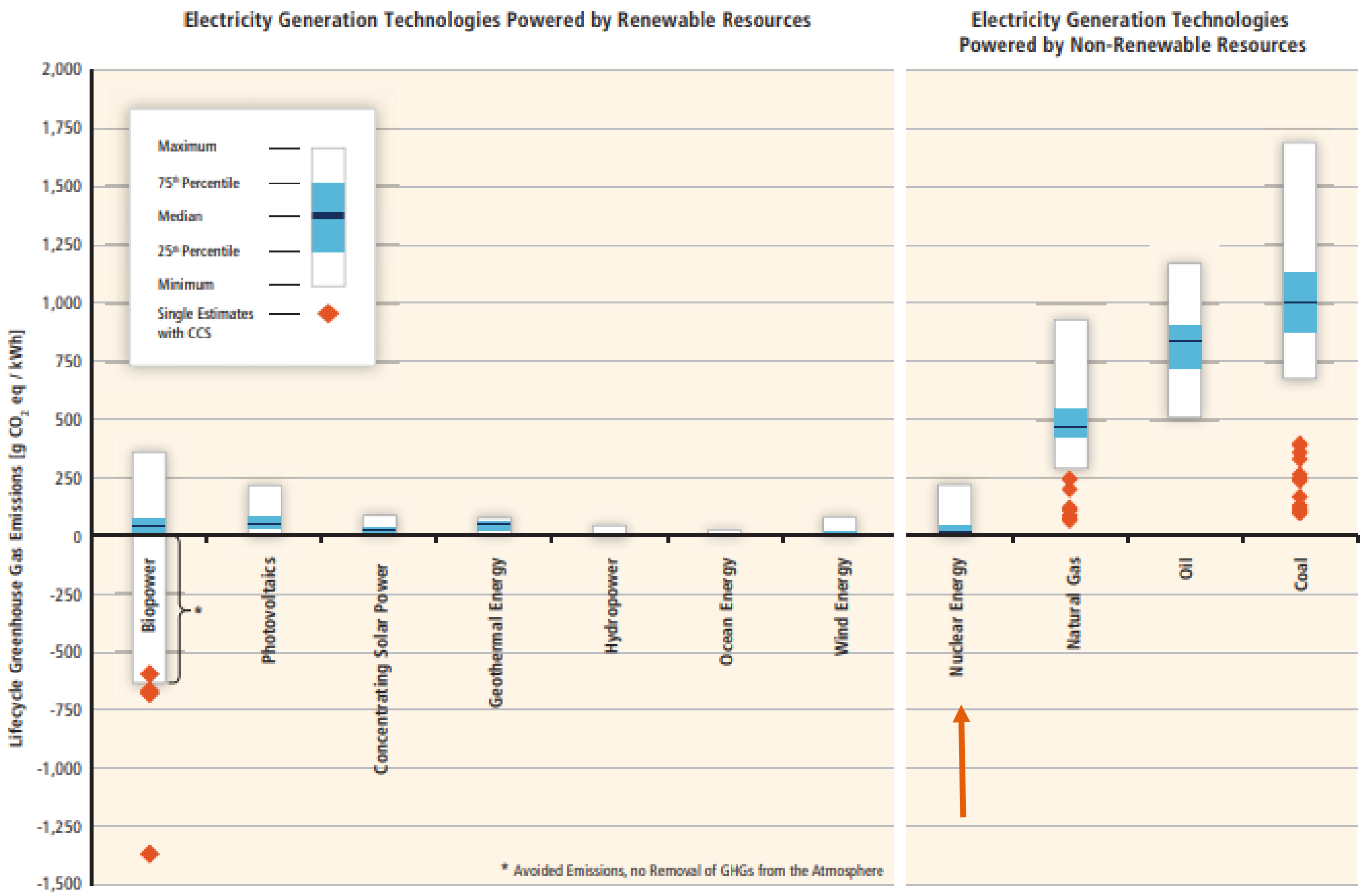

Figure 3-6 Emissions of greenhouse gases during the life-cycle of different electricity producers. Source: IPCC.

The above graphic shows that over the entire life-cycle, emissions of greenhouse gases for nuclear energy (see the orange arrow) are far lower than for electricity from natural gas, oil or coal (the bars to the right of nuclear energy). Across all the studies included in the analysis by the IPCC, the median value for nuclear energy is approximately 10 grams of CO_2 equivalent per kilowatt-hour (kWh). This makes emissions for nuclear energy over the entire life-cycle many times lower than for fossil sources such as coal (~1000 grams CO_2/kWh) or natural gas (~450 grams CO_2/kWh), and of the same order as emissions for wind energy (approximately 10 grams CO_2/kWh). Nuclear energy is therefore not CO_2-free, but according to the most recent studies, the CO_2 emitted over the entire life-cycle is just as low as for wind energy and much lower than for fossil electricity. The graphic also shows that the IPCC included a small number of studies in which the estimated emissions for nuclear energy were substantially higher. In those studies, the most unfavourable assumptions were made for the various aspects. More recent studies (for example by Pomponi and Hart, 2021[27] and UNECE, 2021[28]) also show that CO_2 emissions for nuclear energy are tens of times lower than for fossil electricity.

[27] Francesco Pomponi, Jim Hart, The greenhouse gas emissions of nuclear energy – Life cycle assessment of a European pressurised reactor, Applied Energy, Volume 290, 2021 The greenhouse gas emissions of nuclear energy – Life cycle assessment of a European pressurised reactor - ScienceDirect

[28] Carbon Neutrality in the UNECE Region: integrated Life-cycle Assessment of Electricity Sources, UNECE, 2021. LCA_3_FINAL March 2022.pdf (unece.org)

3.3.3 The Borssele nuclear power plant in comparison with other nuclear power plants

A new nuclear power plant is generally safer than (existing) nuclear power plants built earlier. Thanks to improved understanding of accident scenarios, new nuclear power plants are designed to cope with major accidents. However, the Borssele nuclear power plant has been modified in the light of the new insights and requirements. The Borssele plant is among the 25 per cent safest pressurised water nuclear power plants in the Western world.

In 2006, the Borssele Nuclear Power Plant Covenant was signed, in which the owner of the Borssele nuclear power plant committed to ensuring that the Borssele nuclear power plant would be among the 25% safest technically comparable power reactors in the European Union, the United States and Canada – the so-called safety benchmark. To this end, in 2008 a commission of independent international experts was set up, the Benchmark Commission, which verifies compliance with the safety benchmark every five years and reports back to the parties to the covenant. The safety benchmark of Borssele nuclear power plant from 2023 concludes as follows: *The Commission has compared the safety of 220 nuclear power plants using the comprehensive methodology developed. Based on that comparison, the Commission has unanimously concluded that the Borssele nuclear power plant is among the 25% safest water cooled and water moderated reactors in the EU, US and Canada*[29]*.*

[29] https://www.tweedekamer.nl/downloads/document?id=2024D12173

4 Proposed activity

4.1 Objective

The Netherlands has set itself the target to be climate-neutral by 2050. According to the National Energy System Plan (NPE), this means that the Netherlands' electricity system must already be CO_2-neutral by 2035. In order to achieve this objective, solar, wind and nuclear energy sources need to be scaled up. For nuclear energy, scaling up in concrete terms means extending the operating life of the Borssele nuclear power plant, provided it can be demonstrated that this can be done safely.

As a first step towards an operating life extension for the Borssele nuclear power plant, the Nuclear Energy Act needs to be amended. Section 15a of the Nuclear Energy Act stipulates that part of the Nuclear Energy Act permit for maintaining the Borssele nuclear power plant in operation expires on 31 December 2033, i.e. the part pertaining to the release of nuclear energy. The second subsection stipulates that no application will be considered for a licence for the release of nuclear energy by the plant after 31 December 2033. This means that Section 15a of the Nuclear Energy Act stands in the way of an operating life extension for the Borssele nuclear power plant beyond 2033.

This legislative proposal amends Section 15a of the Nuclear Energy Act and clears the way for a potential permit application to extend the operating life of the Borssele nuclear power plant. Once the Act has been amended, the operator of the nuclear power plant will apply to the Authority for Nuclear Safety and Radiation Protection (ANVS) for a permit. The decision to apply for the permit lies with the operator and the shareholders of the nuclear power plant. As such, the operating life extension – along with the legislative amendment – is dependent on the submission of a permit application by the operator, the assessment of the application and the award of the permit by the ANVS.

This Environmental Impact Assessment (EIA) Phase 1 provides the environmental information needed to give proper consideration to the environmental interests in decision-making on the legislative amendment. The EIA informs the competent authority about the environmental situation with regard to existing operations. It also contains an extrapolation of environmental impacts after 2033 (where possible) and an agenda listing environmental aspects which are relevant to the next phase of the licensing process.

4.2 Legislative proposal

The proposed activity is a legislative amendment to the Nuclear Energy Act that would enable a permit application to further extend the operating life of the Borssele nuclear power plant. This means that the obstacle to a new permit application which is currently contained in the legislation will be removed. The new Section 15a of the Nuclear Energy Act and the Explanatory Memorandum are included in Annex 1.

5 Exploratory study

5.1 Methodology

The amendment to the Nuclear Energy Act enables a potential permit application to extend the operating life of the Borssele nuclear power plant. This Environmental Impact Assessment (EIA) describes the environmental impacts of the nuclear power plant. Environmental impacts can take different forms, such as pollution of air, water and soil, depletion of natural resources and loss of biodiversity and (nuclear) safety. Mapping out the existing environmental impacts of the Borssele nuclear power plant will produce relevant insights into the potential environmental impacts of the legislative amendment. The environmental impacts of the Borssele nuclear power plant and the knowledge gaps identified together make up an agenda of environmental issues to be considered in a potential EIA Phase 2.

The description of the environmental impacts consists of four steps for each aspect:

- Identifying possible environmental impacts (i.e. could this environmental impact occur?).
- Where possible, quantifying the environmental impacts based on statutory and/or licensed frameworks.
- Where possible, extrapolating environmental impacts.
- Drawing up an agenda of studies, actions and knowledge gaps for Phase 2.

The environmental annual reports of EPZ are one of the sources that will be used to shed light on the existing environmental impacts of the Borssele nuclear power plant. The environmental annual reports of the Borssele nuclear power plant are publicly accessible.[30] The existing situation is defined as the period from 2017 to 2022. This period is representative of the situation as it currently pertains at the Borssele nuclear power plant. The existing ecological situation is an exception to this. The 'existing ecological situation' is defined as the situation today, i.e. up to and including the time of writing of this report (early 2024).

The developments and trends over the past decade and decades will be taken into account, depending on the available data; see also Section 0. The existing permits of the Borssele nuclear power plant, in combination with the existing public law rights, describe the maximum permitted environmental impacts. No calculations have been performed for this EIA Phase 1, but where possible the environmental impacts have been described using existing statutory or licensed frameworks. The only exception to this is the AERIUS calculation for nitrogen deposition in Natura 2000 areas.

5.2 Relevant environmental impacts and assessment framework

The operation of the Borssele nuclear power plant has potential impacts on different environmental aspects:

- Extraction and discharge of cooling water.
- Disturbance on land and water caused by production of noise, light and/or movements.
- Turbidity and sedimentation.
- Pollution resulting from the release of non-native substances.
- Production of noise.
- Production of nitrogen oxides and CO2.
- Exposure to radiation.
- Impact on the chemical and thermal quality of the surface water.
- Extraction of groundwater.

Various environmental impacts of the Borssele nuclear power plant are relevant to the nature, radiation protection, nuclear safety, water, soil, noise, health and safety aspects. In the following chapters, the criteria are explained for each aspect. All the criteria taken together make up the assessment framework.

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[30] WOO-besluit verzoek Laka over milieujaarverslagen EPZ | Woo-besluit | Autoriteit NVS

The operation of the Borssele nuclear power plant has no impacts on cultural history and archaeology and has no spatial or visual impacts. The plant has been located on the Borssele industrial estate since the 1970s. The impacts on landscape, cultural history and archaeology occurred at the time of its construction. The EIA is based on the continuation of the existing situation. We therefore assume that no additional land beyond the existing Borssele nuclear power plant site will be used and that for this reason there will be no new impacts on cultural history, archaeology, recreation, etc.

5.3 Planning area and study area

The planning area is the location of the Borssele nuclear power plant. However, the environmental impacts of the plant may extend beyond this area. The study area is the area within which environmental impacts occur. This is the impact area of the legislative amendment. The study area varies from one environmental aspect to the next. Its boundaries depend on the nature, size and extent of the impacts. In the substudies, the study area is specified and explained for each topic.

5.4 Developments

Seven National Coordination Procedures for major energy projects are currently under way in the municipality of Borsele. Section 2.3 includes a table that provides an overview of the (regional) strategic decisions taken/to be taken on national energy projects. The Borssele nuclear power plant may have impacts on future energy plans and projects in the area (for instance, the plans for the Borssele Energy Hub and the potential impact on nature in Natura 2000 sites); conversely, these plans and projects may also have an impact on the Borssele nuclear power plant. In the chapters on the aspects, the autonomous developments are not included in the description of the existing situation. Autonomous developments lie in the future. Where relevant, future developments have been included in the extrapolation to the future and the look ahead to Phase 2.

5.5 Chapters on different aspects

The following chapters explore the environmental considerations. A description of the existing environmental situation is followed by an extrapolation to the post-2033 period – where possible, because we do not know the exact details of the operating life extension or how the autonomous developments will turn out. Factors taken into account in the extrapolation include the consequences of climate change, natural trends and the possibility (in the long term) of other future initiatives in the area around the nuclear power plant.

Potential transnational effects of the existing situation have also been mapped out. The chapters conclude with an agenda listing environmental focal points requiring attention in a potential EIA Phase 2. The above information is provided to inform the government and the House of Representatives and Senate of the States General for the purposes of political decision-making.

It is based on the following assumptions and sources:
- The period from 2017 to 2022 has been used for the description of the existing situation.
- Use has been made of the environmental annual reports of EPZ, along with measurement and monitoring reports by NRG and other publicly accessible information.

6 Ecology

6.1 Introduction and reader's guide

This chapter focuses on the aspect of ecology. The goal of this chapter is to outline the potential environmental impacts of the existing Borssele nuclear power plant (KCB) on ecology, based on the existing activities of the plant. The level of detail of the studies and assessment are in line with this goal. The insights obtained in this chapter into the potential environmental impacts of the Borssele nuclear power plant will be used to help guide the subsequent EIA Phase 2 if it goes ahead; in it, the impacts will be studied and assessed in more detail. A summary of the potential environmental impacts of the Borssele nuclear power plant on ecology follows in Section 6.6.

In order to obtain a good picture of the environmental impacts of the plant on ecology, in this chapter we examine various ecological aspects in a systematic manner. Firstly, in Section 6.2 we discuss the ecological framework based on which we are exploring the potential environmental impacts on the ecology. This framework consists of ecological values which are legally protected under Natura 2000, the Water Framework Directive, Flora and Fauna and the Zeeland Nature Network (NNZ). It encompasses the biotic communities, biotopes and species which are most vulnerable and characteristic of the local ecosystem, the whole of the Netherlands and even the EU. By considering the protected ecological values which are relevant around the Borssele nuclear power plant, we can obtain a representative picture of the most relevant ecological aspects for this report. Viewing the environmental impacts of the operation of the Borssele nuclear power plant in this context will enable us to clarify the environmental impacts on the surrounding ecosystem. National borders are not relevant in this regard, since the ecological values in question are not confined by national borders and are therefore transboundary in nature.

In Section 6.3, we set out the criteria based on which we will map out the environmental impacts of the Borssele nuclear power plant on ecology. The criteria are based on the activities of the Borssele nuclear power plant during regular operations, for example the intake and discharge of (heated) cooling water. Such activities can have an impact on ecology. We also consider the potential influence of the criterion in question on biotic factors. For example, when drawing in water, fish can potentially also be drawn into the intake. We then identify how this relates to the ecological framework sketched out in the previous section. After this, we focus on these intersections between biotic communities and criteria.

In order to establish which elements of the ecological framework are especially vulnerable, or relatively robust, we consider the existing status of the ecology in and around the Western Scheldt in Section 0. We do so per biotic community (for instance, fish, birds, etc.). By shedding light on the existing situation, we are able to reveal where the vulnerable points in the ecosystem around the Borssele nuclear power plant lie. In Section 6.5, we consider the expected changes to the future environmental situation, and how these autonomous factors may influence the ecological situation around the Borssele nuclear power plant. This leads to an extrapolation of the current situation regarding ecology.

Finally, in Section 6.6 we bring all this information together. This brings the main issues requiring attention for EIA Phase 2 into focus. We emphasise that this is not definitive. Assessments in greater detail, which will be part of EIA Phase 2, will be required to determine whether effects are acceptable or not.

Finally, Section 6.7 ‘Outlook for EIA Phase 2’ contains the conclusions of the chapter on ecology. In it, we identify the most important ecological focal points requiring attention in EIA Phase 2, along with knowledge gaps and other relevant matters in the context of permissibility and ecology. The issues listed provide a basis for an ecological assessment in EIA Phase 2.

6.2 Ecological framework

In this section, we explain the framework for the ecology chapter. Using this framework, we shed light on the environmental impacts of the Borssele nuclear power plant on the ecology.

In the Netherlands, nature is protected under different frameworks. We consider the following frameworks:

- Natura 2000.
- Water Framework Directive.
- Flora and Fauna (protected species).
- Zeeland Nature Network.

Not all facets of nature are protected under these frameworks. Generally speaking, they focus on a selection of characteristic and vulnerable biotic communities, biotopes and species. The reason is that these characteristic and vulnerable biotic communities, biotopes and species require specific conditions for their survival. Only if those conditions are in order and remain assured can the defined objectives be achieved. Less vulnerable ecological values often benefit along with the protected ecological values. The selection of relevant ecological values is also applicable to nature in neighbouring countries. After all, species and biotopes take no account of national borders.

We would like to emphasise that the legal nature protection frameworks cited have been used to provide a good indication of the relevant ecological values around the Borssele nuclear power plant and not as a concrete legal assessment framework. By comparing the consequences of the operation of the Borssele nuclear power plant against this ‘ecological framework’, we are able to obtain a representative picture of the potential environmental impacts on the ecosystem.

6.2.1 Natura 2000

The Minister of Agriculture, Nature and Food Quality designates Natura 2000 areas. All areas are selected on the basis of the occurrence of species and habitat types (the natural environments required for the survival of those specific species) which require protection in a European context, for example because they perform an important role in the ecosystem. In every decision to designate a Natura 2000 area, conservation objectives are described for the relevant area. These may be conservation objectives under the Wild Birds Directive (birds and their biotopes) and/or the Habitats Directive (habitats and species other than birds and their biotopes).

Figure 6-1 shows the Natura 2000 areas around the Borssele nuclear power plant. The figure shows that there are numerous Natura 2000 areas located in the relative vicinity of the plant. In order to clarify the relevant ecological values around the Borssele nuclear power plant, we have highlighted the ecological values of the immediately adjacent Natura 2000 area Western Scheldt & Saeftinghe and the Natura 2000 area Vlakte van de Raan, which lies >20 km westwards. This provides a good impression of the ecological values protected under the Natura 2000 framework in the area around the plant. Other Natura 2000 areas often display a lot of overlap in terms of protected ecological values and have not been highlighted.

The Natura 2000 area Western Scheldt & Saeftinghe is both a Habitats Directive and a Wild Birds Directive area. It is therefore subject to conservation goals for a large number of estuarine habitat types, such as ‘Permanently flooded sandbanks’, ‘Tidal flats and sandbanks’ and ‘Grey dunes’. These habitat types are important for numerous characteristic marine and estuarine species. Some of those species are also designated as Habitats Directive species, which means targets have been set for them. They include migratory fish such as sea lamprey and twait shad and marine mammals such as the common seal and the harbour porpoise. Conservation objectives have also been defined for a large number of Wild Birds Directive species for the Western Scheldt. These are species which are characteristic for the estuarine system of the Western Scheldt. They include breeding birds such as the common tern, little tern and pied avocet and non-breeding birds such as common shelduck, ruddy turnstone and peregrine falcon. All these habitat types and Habitats Directive and Wild Birds Directive species therefore require specific estuarine conditions and as such are characteristic for the Western Scheldt as an ecosystem. These species have specific requirements in terms of biotope – for example, there need to be sufficient suitable and high quality brooding, resting and/or feeding sites.

The Vlakte van de Raan Natura 2000 area has only been designated as a Habitats Directive area. There are conservation objectives for the habitat type ‘Permanently flooded sandbanks’ in this area. There are also conservation objectives for largely the same estuarine/marine Habitats Directive species as in the Western Scheldt & Saeftinghe Natura 2000 area.

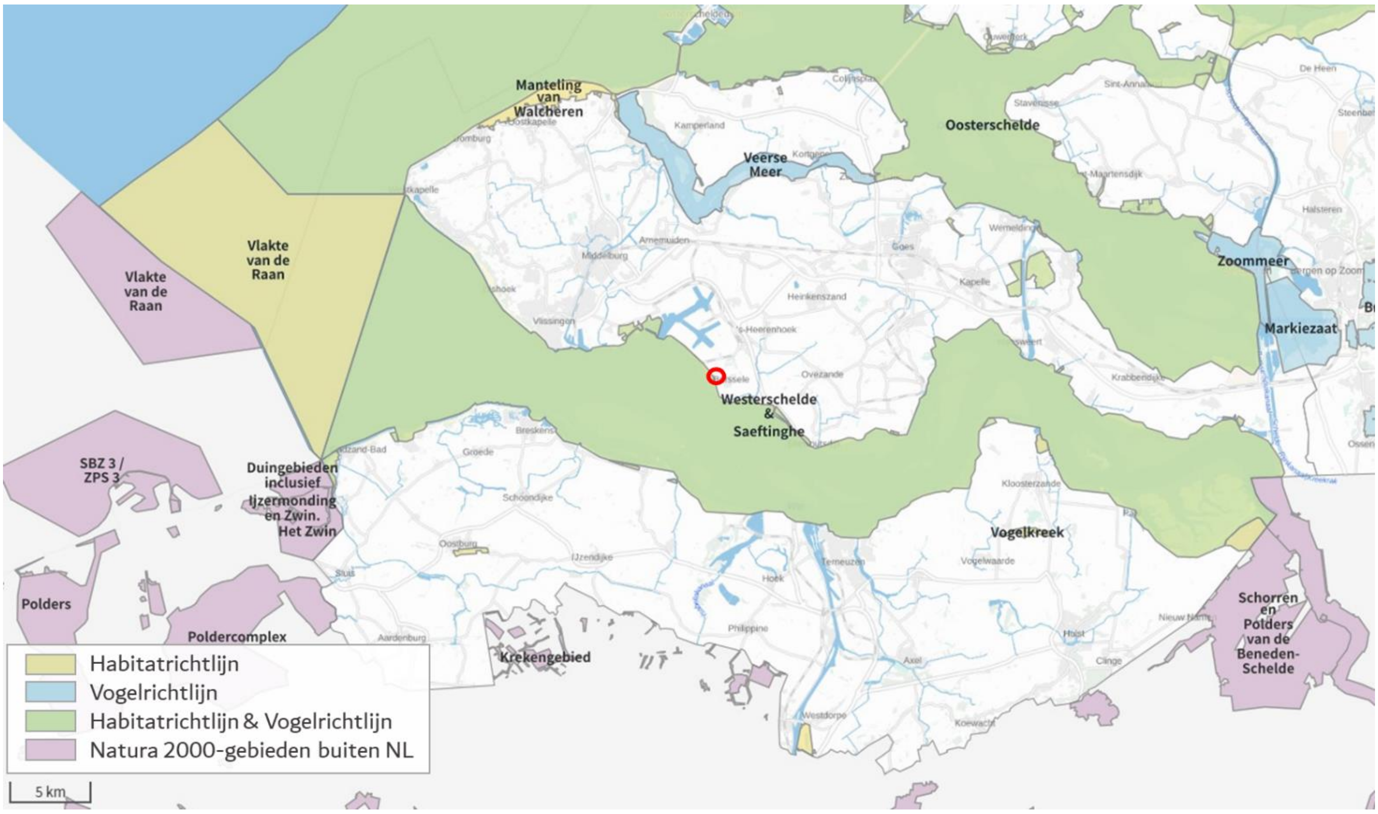

Figure 6-1 Natura 2000 areas around the Borssele nuclear power plant (red circle). Base map from aerius.calculator.nl

Activities affecting a Natura 2000 site are subject to a formal reference point. Normally, the time of granting a (previous) permit of that activity is the reference point. However, KCB does not have a nature or environmental permit. This is because KCB's activities have been conducted in a relatively similar manner since 1973. At most, there are technical adjustments of limited scope. In 2013, for example, operating life extension (LTO = life time operation extension) of the KCB was implemented up to and including 2033. In the present case, where no nature permit is available, the formal reference situation is derived from the moment when the Habitats Directive and/or Birds Directive became applicable to the relevant Natura 2000 site around KCB. This moment differs per designation of the Birds Directive (BD) and/or Habitats Directive (HD) of each Natura 2000 site. The Natura 2000 sites relevant to this report are listed below.

- Westerschelde & Saeftinghe
  - Onderdeel Westerschelde VR 2000 HR 2004
  - Onderdeel Verdronken Land van Saeftinghe VR 1995 -
- Vlakte van de Raan - HR 2009
- Oosterschelde VR 1989 HR 2004
- Yerseke en Kapelse Moer VR 2000 HR 2004
- Manteling van Walcheren - HR 2004
- Voordelta VR 2000 HR 2004
- Zwin & Kievittepolder VR 1996 HR 2004
- Vogelkreek - HR 2004
- Groote Gat - HR 2004
- Canisvliet - HR 2004

From the list above, it is clear that the reference dates differ per Natura 2000 site. For the sake of clarity, this document uses one reference point for the Birds Directive and one for the Habitats Directive around KCB. Here, the time of designation of the Natura 2000 site Western Scheldt & Saeftinghe, located next to KCB, was used (BD 1995 and HD 2004). Since these are not outliers in relation to the other moments of designation, these moments are sufficiently representative.

6.2.2 Water Framework Directive

The objective of the Water Framework Directive (WFD) is to protect the ecological and chemical water quality of water bodies and promote their sustainable use. The aim is that all WFD water bodies should be in a good condition. The condition of WFD water bodies consists of different biotic and the abiotic categories. In this ecology chapter, only the biological quality elements are discussed; these are fish, macrofauna, other water flora and phytoplankton.

The condition of the biological quality elements relates primarily to the quantity and/or quality of the total biotic community (for example, macrofauna or fish) in the total WFD water body. Depending on the water type, the condition is established by monitoring criteria including species composition, species richness, species diversity and/or abundance at representative measurement points throughout the water body (Foundation for Applied Water Research (STOWA), 2018). The WFD is therefore not so much concerned with individual (rare) species as with entire biotic communities. The condition is summarised in a single score: the Ecological Quality Ratio (EQR score). The scale used ranges from 0 to 1. Depending on the EQR score, the condition is classed as ‘good’, ‘moderate’, ‘poor’ or ‘bad’. The boundaries between these classes can differ depending on the FWD water body in question.

Figure 6-2 shows the WFD water bodies around the Borssele nuclear power plant. The Borssele nuclear power plant borders the WFD water body Western Scheldt. To the west, the WFD water body Western Scheldt transitions into the WFD water body Zeeland coast (coastal water). The goals for both water bodies have therefore been taken into consideration in this document.

The WFD water body Western Scheldt belongs to water type O2(a), or ‘*Estuary with moderate tidal difference (with tidal flow and/or without dominant effect of shipping)*’ The WFD water body Zeeland coast (coastal water) belongs to the water type K3, or ‘*Coastal water, open and euhaline*’. The difference in type means that different objectives apply to the two water bodies, which also have (slightly) different compositions. For the Western Scheldt WFD water body, all four biological quality elements apply: phytoplankton, other water flora, macrofauna and fish. For the WFD water body Zeeland coast (coastal water), two biological quality elements apply: phytoplankton and macrofauna.

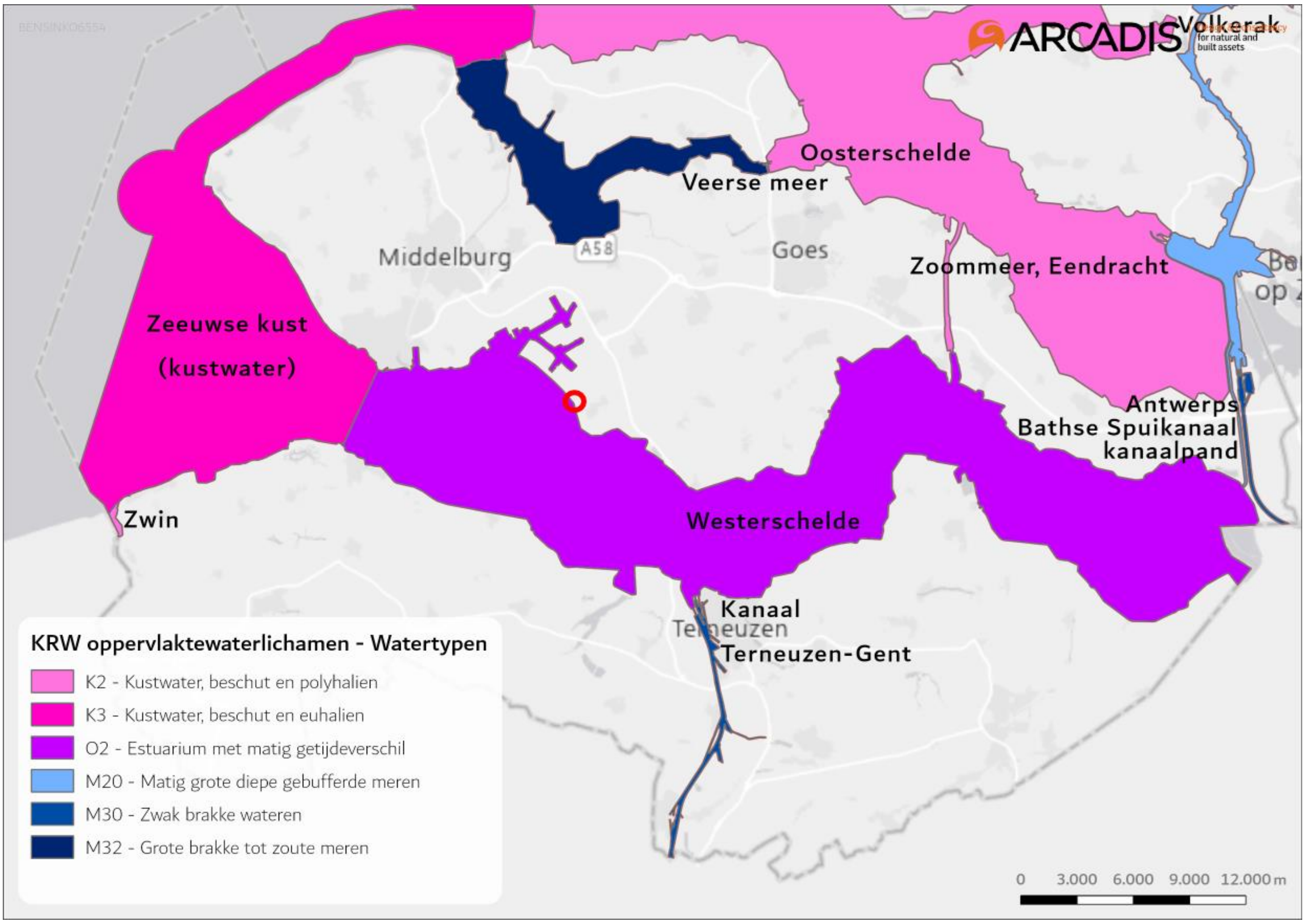

Figure 6-2 WFD water bodies around the Borssele nuclear power plant (red circle). There are also WFD water bodies in Belgian waters: these are not shown on the map

6.2.3 Flora and Fauna

A large number of species are protected by the Environment and Planning Act under the term 'Flora and Fauna'. The protected species are divided into three protection categories; several examples of species/species groups are given for each category:

- **Wild Birds Directive species** (European level): All birds that naturally live in the wild. In other words, all species.
- **Habitats Directive species** (European level): A selection of animals and plants that naturally live in the wild. These are species that require protection at the European level, for example because the survival of healthy populations in nature is under threat. They comprise a large number of species within species groups such as (migratory) fish, marine mammals, bats, plants, insects, amphibians and land-based mammals.
- **Other species** (nationally protected species, Living Environment (Activities) Decree, Section 11.2.4): Alongside the species whose protection has been made mandatory at European level, there are also species which are protected at national level. These are species which are rare and/or endangered in the Netherlands, as a result of which their long-term survival is not assured if no protection measures are taken. Again, they comprise a large number of species within different species groups such as those listed above.

The protected species are not subject to any specific Flora and Fauna Act objectives. Their protected status does indicate that they are at risk to some extent, for example because the specific conditions they require for their survival are no longer sufficiently available. For this reason, the ecological values which are protected under Flora and Fauna have been taken into account.

6.2.4 Netherlands Nature Network

The Netherlands Nature Network (NNN) is the Dutch network of existing and proposed areas of high ecological value. The objective of the NNN is to better connect such areas with each other and with the surrounding agrarian areas. A further objective is to preserve the ecological values of the NNN areas. Within the province of Zeeland, the NNN is also known as the Zeeland Nature Network (NNZ). The NNZ comprises four categories for which ecological values have been specified in the form of essential characteristics and values:

- Existing nature (including Delta waters).
- Agrarian area of ecological importance.
- New nature.
- Nature projects (conservation projects and area-based projects).

Figure 6-3 and Figure 6-4 show the NNZ around the Borssele nuclear power plant. The NNZ is subdivided according to the above categories and by management type.

All the large bodies of water, including the south-western Delta, fall under the ‘existing nature in Delta waters’ category. Rather than the provincial authority, the national government has responsibility at system level for the nature in large bodies of water[31]. The national government assures the ecological values in these large bodies of water by means of the objectives elucidated previously under the WFD, Natura 2000 and Flora and Fauna. As a result, the NNZ is not relevant to the large bodies of water as an ecological framework.

However, the NNZ is relevant as an ecological framework for nature on land, with the objective being to preserve the existing ecological values within the NNZ. This applies to the characteristics and values corresponding to the management types on land, as depicted in Figure 6-4 – for example, important characteristics of management type ‘N08.01 Beach and embryonic dune’ (Figure 6-4: area shown in yellow in the vicinity of inlet and outlet) including the number of qualifying (characteristic) plants and breeding birds present and the degree of nitrogen deposition load.

[31] www.rijksoverheid.nl/onderwerpen/natuur-en-biodiversiteit/natuurnetwerk-nederland

Figure 6-3 Zeeland Nature Network, subdivided by the categories listed above, around the Borssele nuclear power plant (broadly outlined in red). According to the Zeeland Nature Management Plan 2024, from https://kaarten.zeeland.nl/map/atlasvanzeeland

Figure 6-4 Zeeland Nature Network, subdivided by management type, around the Borssele nuclear power plant (broadly outlined in red). According to the Zeeland Nature Management Plan 2024, from https://kaarten.zeeland.nl/map/atlasvanzeeland

6.3 Criteria

This chapter briefly explains the possible environmental impacts of the operation of the Borssele nuclear power plant which are relevant in the context of ecology. These are the possible environmental impacts shown in Table 6-1. The purpose of this section is to provide sufficient information on all the consequences so that it can be used to identify the environmental impacts in Section 6.6. The consequences are referred to as criteria below.

Table 6-1 Consequences (subsequently referred to as criteria) discussed in the context of ecology

Consequence/criterion	Notes
Extraction and discharge of cooling water	The extraction of cooling water, the mechanical filtering of cooling water and the discharge of (heated) cooling water during the regular operating situation of the Borssele nuclear power plant
Disturbance and damage/harm	Production of noise, light and/or movements above and below water during the regular operation of the Borssele nuclear power plant. Physical damage during the movement or other use of equipment also falls within this criterion. The disturbance and/or damage/harm in question relates to biotopes, animals and/or plants.
Turbidity and sedimentation	Causing sediment to become suspended (turbidity) and eventually re-deposited (sedimentation). In the context of the Borssele nuclear power plant, this is primarily relevant in connection with dredging and dispersion activities.
Pollution	The release of non-native substances into the environment, excluding radioactive substances, during the regular operation of the Borssele nuclear power plant.
Radiology	The release of radioactive substances during the regular operation of the Borssele nuclear power plant.
Nitrogen deposition	The release of nitrogenous gases (NO_x and/or NH_3) from the deployment of equipment such as vehicles and generators. Over time, the nitrogen precipitates in the surrounding area; this is called nitrogen deposition.

The criteria are all based on the regular operating situation of the Borssele nuclear power plant. Where possible, references are made to other chapters, for example with regard to hydrology. This has been done in order to avoid repeating information from other disciplines in this chapter as far as possible.

The following information is considered:

- **Potential influence on biotic factors**: The influence that the criterion in question could potentially have on biotic factors and how this occurs.
- **The situation of the Borssele nuclear power plant**: The extent to which the criterion in question is released in the course of the activities of the Borssele nuclear power plant.
- **Intersections with the ecological framework**: The intersections between the criterion and the ecological framework (Section 6.2). The environmental impacts of those intersections are specified. If there are no such intersections, there are no anticipated environmental impacts or they may be assumed to be negligible. In such cases, the criterion in question has not been discussed further.

Following the consideration of all the criteria, Section 6.3.7 summarises the intersections between the criteria and the ecological framework.

6.3.1 Extraction and discharge of cooling water

6.3.1.1 Potential influence on biotic factors

Intake and mechanical filtering of cooling water
The intake and mechanical filtering of cooling water can result in the killing of individuals (such as one or more fish). If large numbers are involved, this can influence species at population level and the interactions in the (local) ecosystem.

When drawing in cooling water, organisms are also drawn in. Depending on their size, they end up in the filters which are present. These organisms primarily comprise biotic communities and organisms in stages of life with very limited swimming capacity, such as phytoplankton, zooplankton and smaller species of fish (Bruijs & Taylor, 2011). The zooplankton category also includes the larvae and eggs of numerous aquatic species of animals within the macrofauna, fish and aquatic invertebrates groups. The eggs and larvae occur in suspended form in the water column, allowing them to be moved by the current. Organisms which find their way into the cooling water inlet channel experience turbulence and a relatively rapid increase in ambient temperature. As a result, some of those organisms will not survive. If large quantities of water and the flora and fauna they contain are drawn in, this can have an impact at population level (Bruijs & Taylor, 2011; Vriese et al., 2012), and hence on the interactions in the food chain within the local ecosystem, which can in turn lead to certain environmental impacts.

Discharge of (heated) cooling water
The discharge of heated cooling water can exert an influence on the local ecosystem.

The discharge of heated cooling water causes a change in abiotic factors around the discharge point. The temperature of the water is higher at this point. Some species prefer such conditions or are sufficiently tolerant of them; others are less well adapted to them and avoid them. Locally, this can lead to changes in densities, biomass and species composition of particular species/species groups or biotic communities (IAEA, 1980), which means there can be environmental impacts.

6.3.1.2 Extraction and discharge of cooling water by the Borssele nuclear power plant

The volumes of cooling water extracted and discharged by the Borssele nuclear power plant are regulated by the water permit (reference: RWS/218-48580).

Water is drawn into the cooling water intake building from the Western Scheldt; there, the cooling water system splits into a primary cooling water system (67,000 m3/h) and an emergency and secondary cooling water system (4,200 m3/h). Before the cooling water reaches the main and secondary cooling water pumps, it is first mechanically filtered by means of meshes ranging from very coarse to very fine. Everything that ends up in the meshes is filtered from the water. There is no system to return fish to the Western Scheldt.

The extraction of cooling water for the primary cooling water system takes place at all times with the exception of a period of between three and six consecutive weeks a year when the nuclear fuel is changed. The extraction of cooling water for the emergency and secondary cooling water systems does take place continuously, i.e. 24 hours a day, 365 days a year.

The two systems come back together in the cooling water discharge building, after which the heated cooling water is discharged back into the Western Scheldt by means of overflow. Article 5 of the water permit states that the debit of the discharge water flow may not exceed 23.2 m^3/s (83,520 m^3/h). As a result of the turbulence during overflow, the discharge water is relatively oxygen rich.

The water permit does not set a limit for the temperature of the cooling water returned to the Western Scheldt. There is a limit for the maximum heat (the quantity of energy transferred): 980 MW_{th}. This means that the maximum temperature of the cooling water returned to the Western Scheldt is dependent on the temperature of the water drawn in. The most recent environmental annual report reveals that the heat emitted to the Western Scheldt in 2022 averaged 807 MJ/s.This equates to an average increase of 10.3 ^{o}C compared to the temperature of the surface water.

6.3.1.3 Intersections with the ecological framework

The quantities of cooling water which the Borssele nuclear power plant draws in, heats up and discharges back into the Western Scheldt can cause various environmental impacts. There is a risk of individuals being harmed or killed by being drawn in. There is also a risk of influencing species at population level and interactions in the (local) ecosystem, in particular with regard to species whose staple diets consist of macrofauna and/or fish. This is related to the following aspects of the ecological framework:

- Natura 2000
  - Habitat types: The quality of habitat types in water and the intertidal zone (by influencing their proper structure and functioning and the characteristic species present).
  - Habitats Directive species: Migratory fish, marine mammals.
  - Birds Directive species: Breeding and non-breeding birds.
- Flora and Fauna
  - Migratory fish (whitefish and sturgeon).
- WFD
  - Phytoplankton.
  - Macrofauna.
  - Fish.

6.3.2 Disturbance and damage/harm

6.3.2.1 Potential influence on biotic factors

Disturbance can be caused by noise, light and the presence of moving equipment or persons (visual disturbance). Disturbance can lead to stress and/or flight of animals, which can then result in animals avoiding biotopes for a shorter or longer period of time. Ultimately, this can result in a fall in reproduction or to an increase in mortality (Hawkins & Popper, 2017). Species may start displaying habituation and/or tolerance to disturbance if it is of a continuous or regular nature (Krijgsveld et al., 2022).

In addition, the use of equipment such as vehicles can cause harm to biotopes, animals and/or plants. Animals and plants may be harmed or killed. Damage can also result in biotopes becoming temporarily or permanently unsuitable.

6.3.2.2 Disturbance caused by the Borssele nuclear power plant

Above water
Daily movements of employees, vehicles and equipment on the Borssele nuclear power plant site represents an important source of disturbance through noise, light and/or movements and damage. By way of indication, an AERIUS calculation was performed for the nitrogen deposition component, based on the assumption of 250 cars and 29 trucks accessing the site every day (see Annex 2).

The production of noise is governed by regulations G82 to G88 of the Nuclear Energy Act permit. The most important is regulation G82, which specifies maximum values of up to 62 dB(A). The Guidelines on Industrial Noise and Licensing (*Handreiking industrielawaai en vergunningverlening*) (revised permit point 5.4.8) also state that 'efforts must be made' to prevent maximum noise levels which are more than 10 dB above the existing equivalent level, with an upper limit of 70, 65, 60 dB(A) for daytime, evening and night-time, respectively. These values apply at the façades of residences and other noise-sensitive locations. The nearest house is 250 m away.

No concrete information is available about disturbance during regular operations of the Borssele nuclear power plant. It is assumed that the site is continuously lit during the hours of darkness.

In conclusion, no complete information is available about the extent of disturbance and damage/harm above water. It is assumed that disturbance as a result of noise, light and/or movements and harm/damage in any event occurs daily to some extent on and immediately around the site of the Borssele nuclear power plant.

Underwater
There will also be underwater disturbance during the annual dredging of the cooling water intake channel (further detailed in Section 6.3.3), caused by both the ship's engines and the dredging itself. There may also be some underwater disturbance around the cooling water inlets and outlets as a result of increased noise levels due to the turbulent water. The environmental impacts of this are assumed to be negligible. This is because the Borssele nuclear power plant is located a short distance from the navigation channel of the Western Scheldt, which is in constant use by large seagoing vessels. The Sloehaven docks are also located a relatively short distance away. Underwater disturbance is therefore not considered further.

6.3.2.3 Intersections with the ecological framework

The disturbance and damage/harm caused during the regular operation of the Borssele nuclear power plant is clear to a limited extent. In the worst case there are intersections with the following aspects of the ecological framework:
- Natura 2000
  - Habitats Directive species: Common and grey seal
  - Birds Directive species: Breeding and non-breeding birds.
- Flora and Fauna
  - Flora (including smooth cat's ear and greater butterfly-orchid).
  - Birds (including various species of general breeding birds and coastal nesting birds).
  - Bats (including common pipistrelles).
  - Land-based mammals (including hare and mustelids).
  - Marine mammals (including common seal).
  - Amphibians (including natterjack toad).
- NNN
  - Surrounding NNZ area: Essential characteristics and qualities.

Relevant autonomous conditions
The disturbance and damage/harm that occurs during the regular operation of the Borssele nuclear power plant is relatively limited with regard to other disturbing factors in the surrounding area. The Borssele nuclear power plant is located beside the large and busy industrial area around the Sloehaven docks. The biotic factors in the Western Scheldt which are sensitive to disturbance have had to learn to live with this to a certain extent and will be tolerant to it up to a point. This will be taken into account when determining the environmental impacts later in this chapter.

6.3.3 Turbidity and sedimentation

6.3.3.1 Potential influence on biotic factors

Turbidity
Turbidity can lead to reduced transparency at the water's surface; a direct result of this is the inhibition of primary production (i.e. the basis of the food chain). The feeding success of fauna that hunt by sight (birds, fish) can also be negatively affected as a result. In addition, turbidity can have consequences including inhibition of the food intake of filter feeders (organisms that live on plankton and other organic material suspended in the water) (Essink et al., 1990; Kiørboe et al., 1981; Wilber & Clarke, 2001). Migratory fish may also be affected by turbidity if they experience an area of turbidity as a barrier (Bisson & Bilby, 1982).

Sedimentation
Sedimentation can have a direct impact on the bottom life present. If it takes place too rapidly, sedimentation can lead to suffocation of the bottom life (Bijkerk, 1988; Baan et al., 1998; Rozemeijer & Smith, 2017). This may impact the composition of bottom dwelling fauna (Harvey et al., 1998), which can have a knock-on effect on the supply of food for fish and foraging birds. Sedimentation can also cause accelerated raising of mudflats and salt meadows in the area, causing these habitats types to change at an unnatural rate.

6.3.3.2 Turbidity and sedimentation caused by the Borssele nuclear power plant

The Borssele nuclear power plant has a permit under the Water Act to dispose of 90,000 m^3 of dredging spoil in the designated disposal sites in the Western Scheldt annually (Wtw14221/RWS -2013/44347). The dredging spoil originates from the cooling water inlet channel. Dredging of the cooling water inlet channel is essential because sediment from the Western Scheldt is continually being deposited in this relatively low-dynamic harbour basin. This is a natural process. By means of dredging, the supply of sufficient cooling water through the channel is guaranteed. The quantities dredged and dispersed in practice are lower than the maximum and are shown in Table 6-2.

Table 6-2 Overview of the dredging spoil dredged up from the cooling water inlet channel and dispersed in the Western Scheldt annually between 2018 and 2022

Dredging waste dredged and dispersed annually (m^3)					
2018	**2019**	**2020**	**2021**	**2022**	**Annual average**
51,502	17,391	45,805	52,789	31,948	**39,887**

The lightest particles in the sediment (silt) can remain in suspension for a long time. Turbidity plumes as a result of the dumping of sediment in the westerly section of the Western Scheldt extend some 10 km east and west of the dumping site (moving with the incoming and outgoing tides) (Van Kessel et al., 2013a). After being transported by the tides for a shorter or longer period of time, the silt can end up throughout the entire Western Scheldt (Baptist et al., 2006). The silt settles permanently mainly on the relatively low-dynamic areas of the Western Scheldt. These are especially the harbours, and to a lesser extent e.g. sheltered parts of banks, sandbars and mudflats (Van Kessel et al., 2013b). The fraction of heavier particles in the sediment (the sand) is heavier and therefore sinks relatively quickly and locally. This is demonstrated by the simulations by Van Kessel et al. (2013a). The distribution of sand is contained within a few kilometres of the relevant dumping site.

6.3.3.3 Intersections with the ecological framework

The quantities of sediment dredged and dumped for the maintenance of the Borssele nuclear power plant cooling water inlet can result in environmental impacts. There is a risk of killing macrofauna, influencing species at population level and influencing interactions in the (local) ecosystem, in particular for species whose diets consist of macrofauna or fish. This is related to the following aspects of the ecological framework:

- Natura 2000
  - Habitat types: The quality of habitat types in water and the intertidal zone (by influencing their proper structure and functioning and the characteristic species present).
  - Habitats Directive species: Migratory fish, marine mammals.
  - Birds Directive species: Breeding and non-breeding birds (birds that hunt for fish and macrofauna by sight).
- Flora and Fauna
  - Migratory fish (whitefish and sturgeon).
  - Birds (birds that hunt for fish and macrofauna by sight).
- WFD
  - Phytoplankton.
  - Other water flora.
  - Macrofauna.
  - Fish.

Relevant autonomous conditions

The turbidity and sedimentation caused by the regular operation of the Borssele nuclear power plant is relatively limited compared to turbidity and sedimentation in the Western Scheldt in the autonomous situation. As an estuary, the Western Scheldt has a relatively high concentration of suspended matter (turbidity), which is also subject to a high degree of variation (Flemish-Dutch Scheldt Commission, 2023a). The variation in turbidity is caused in part by the natural variation in the flow of the Scheldt and tidal conditions. Moreover, all the harbour basins and the navigation channel are regularly dredged, as a result of which several million cubic metres of dredging waste is dispersed in the Western Scheldt on an annual basis (Flemish-Dutch Scheldt Commission, 2023a). The biotic factors in the Western Scheldt have had to learn to live with these conditions, and as a result will to a certain extent be able to cope with peaks in turbidity and sedimentation. This will be taken into account when determining the environmental impacts later in this chapter.

6.3.4 Pollution

6.3.4.1 Potential influence on biotic factors

The influence of pollutants on biotic factors is highly dependent on the type of polluting substance and its concentration. The accumulation of contaminants in animal tissue can result in oxidative stress, death of cells (apoptosis) and disruption to the hormone system and cause bones and egg shells to become more fragile. This can lead to negative effects on reproduction, growth and development (of larvae, organs, etc.) (Newman, 2009). As a result of biomagnification or accumulation, some toxic substances accumulate in higher trophic levels of the food chain. By consuming animal species lower down the food chain, the animals repeatedly ingest contaminants, which then accumulate in their bodies.The highest concentration of contaminants may therefore be expected in the apex predators, such as sea mammals or fish-eating bird and fish species. All in all, pollution can result in impacts on populations of species and the ecosystem.

6.3.4.2 Pollution by the Borssele nuclear power plant

By means of cooling water discharge
Various auxiliary substances are used in order to ensure that the processes of the Borssele nuclear power plant function properly. The process auxiliary substances used can be partly recovered or captured from waste flows. The remainder cannot be captured and is discharged into the surface water of the Western Scheldt via the cooling water outflow. The substances in question are Nalco TRAC, iron sulphate, chlorine (bleach), hydrazine, ammonia, boric acid, CZV. These include auxiliary substances used to counteract corrosion of the cooling water system and the growth of organisms ('biofouling'). The maximum concentrations in which the substances may be used and the maximum volumes that may be discharged per year are regulated by the water permit (reference: RWS/218-48580). This and the quantities of the substances discharged into the Western Scheldt in practice is discussed further in Chapter 9 *Water*.

By means of dredging and dispersal
The sediment that is dredged from the cooling water inlet channel and dumped in a disposal site in the Western Scheldt every year can potentially contain contaminants. The dredging and dispersal causes the sediment to return to suspension (in part).

The sediment that is dredged and dispersed originates from the Western Scheldt and has found its way into the relatively low-dynamic cooling water inlet channel as a result of sedimentation. This is a natural process; the Western Scheldt is a water system characterised by the free exchange of sediment between locations as a result of current, wind and tide. Dredging and dispersal moves silt that has sedimented in the cooling water inlet channel since the dredging work of the year before. The possibility of this silt containing contaminants (potentially in excess of the specified maximum levels) cannot be ruled out. After all, it is known that various contaminants are present in the Western Scheldt in concentrations in excess of the specified maximum levels, such as various kinds of PFAS and heavy metals (Ministry of Infrastructure and Water Management, 2023). Many of these substances bind to silt. The dredging up and dispersal of contaminants in historic bottom layers can be ruled out, given that only the sedimented silt layer from the year before is dredged up.

6.3.4.3 Intersections with the ecological framework

The contaminated substances released from the activities of the Borssele nuclear power plant can have various environmental impacts. Contaminated substances can cause various direct and indirect impacts for individuals and populations, possibly leading to reduced reproduction or survival chances. This is related to the following aspects of the ecological framework:

- Natura 2000
    - Habitat types: habitat types in water and intertidal zone.
    - Habitats Directive species: Migratory fish, marine mammals.
    - Birds Directive species: Breeding and non-breeding birds.
- Flora and Fauna
    - Migratory fish (whitefish and sturgeon).
    - Marine mammals.
    - Birds in connection with aquatic environment.

- WFD
  - Phytoplankton.
  - Other water flora.
  - Macrofauna.
  - Fish.

6.3.5 Radiology

6.3.5.1 Potential influence on biotic factors

The influence of radioactive substances on biotic factors is dependent, inter alia, on the activity of the substance and the duration of exposure. In the case of high activity and/or excessive exposure, changes can occur in the growth, development and reproduction capacity of biota (Cannon & Kiang, 2020; Geras'kin et al., 2016; Woodwell, 1962). In this way, the presence of radioactive substances in the environment can also impact on the food chain and the ecosystem.

6.3.5.2 Radiological emissions and radiation from the Borssele nuclear power plant

Chapter 7 Radiation protection during regular operations and chapter 8 Nuclear safety focus extensively on the extent of radiological emissions and radiation caused by the operation of the Borssele nuclear power plant. The reader is referred to those chapters. After considering the emissions and radiation released, chapter 7 concludes that it is unlikely that the operation of the Borssele nuclear power plant has environmental impacts on biota.

6.3.5.3 Intersections with the ecological framework

There are no intersections with the ecological frameworks, given that no impacts on biota are anticipated from radiological emissions and direct radiation.

6.3.6 Nitrogen deposition

6.3.6.1 Potential influence on biotic factors

Nitrogen deposition leads to eutrophication of ecosystems. This means that increasingly eutrophic conditions arise in ecosystems. Sometimes this leads to accelerated growth of plants and succession and encroachment of habitats (Wamelink et al., 2021). This can occur if the nitrogen deposition received by a surface exceeds a critical level for the habitat in question: the Critical Deposition Value (CDV) (Wamelink et al., 2023). Above the CDV, a relatively limited number of fast-growing plants species often benefit – for example, bramble, nettle and various grasses – often at the expense of (more critical and rarer) plant species which prefer more oligotrophic conditions. The result is a reduction in biodiversity.

Habitats which are naturally sensitive to eutrophication are primarily habitats with slow-growing open herbaceous vegetation, which tend to be species-rich. This is because such vegetation communities are adapted to growth conditions of permanent 'nutrient shortage', with growth limited by the quantity of available nitrogen. Examples are the vegetation communities found in dunes and peatland.

Nitrogen deposition also has an acidifying effect (Wamelink et al., 2021). The nitrogen makes the soil and ground water more acidic. As a result, vegetation communities that prefer basal, neutral and/or weakly acidic conditions can disappear. Over time, this can lead to the emergence of a different habitat, with associated consequences for the dependent animal species.

The extent to which nitrogen deposition results in influence on the biotic factors depends on local factors, such as hydrological conditions, phosphorus levels, the degree of acidity and possibly human management.

6.3.6.2 Nitrogen deposition by the Borssele nuclear power plant

During the regular operation of the Borssele nuclear power plant, there are various processes at work and types of equipment used which result in the release of the nitrogenous gases ammonia (NH_3) and nitrogen oxides (NO_x). The main sources of these are the use of emergency power generators and boilers, the venting of ammonia and the use of vehicles for the transport of equipment to and from the site, and for the transport for staff. The degree to which nitrogen from these gases precipitates in the area around the Borssele nuclear power plant on nitrogen-sensitive nature within Natura 2000 areas has been calculated using the AERIUS Calculator distribution model[32] (version 2023.1, the most recent version at the time of writing). The input values used and additional information associated with the AERIUS calculation are described in Annex 2. The results of the AERIUS calculation are included in Annex 3.

The AERIUS calculation reveals that regular operations of the Borssele nuclear power plant lead to nitrogen deposition on nine Natura 2000 areas (Figure 6-5). Habitat types subject to the highest levels of nitrogen deposition from the Borssele nuclear power plant in the Western Scheldt & Saeftinghe Natura 2000 area: up to 5.50 mol N/ha/yr. For habitat types in or near a situation of excess load, the maximum nitrogen deposition is 5.15 mol N/ha/yr.[33] The habitat types which receive this maximum deposition level lie between 100 and 250 m west of the Borssele nuclear power plant (see enlarged image within Figure 6-5). In Natura 2000 areas which are further away from the Borssele nuclear power plant, the maximum nitrogen deposition on habitat types is significantly lower, namely 0.08-0.02 mol N/ha/yr (Figure 6-5).

In Table 6-3 below, the nitrogen deposition is shown in more detail for each Natura 2000 area and habitat type. Also indicated is the Critical Deposition Value (CDV) of the habitat types in question and whether they are subject to excess load in the existing situation. The nitrogen deposition in the background situation has been taken into account, i.e. the nitrogen deposition originating from autonomous sources, such as traffic, agriculture and industry,[34] both from the Netherlands and from abroad. This reveals that much of the nature around the Borssele nuclear power plant is currently in a situation of excess nitrogen load.

It is likely that nature *outside Natura 2000 areas* receives a similar pattern of nitrogen deposition from the Borssele nuclear power plant, as shown in Figure 6-5. That is to say that the nature directly around the Borssele nuclear power plant is expected to receive a maximum nitrogen deposition of approximately 5.5 mol N/ha/yr. As the distance from the Borssele nuclear power plant increases, deposition gradually decreases to 0.00 mol N/ha/yr. It should be noted that the relationship is not linear: because ammonia and nitrogen oxides dilute more and more in the air, the deposition of nitrogen is relatively highest close to the source (RIVM, 2021). At greater distances from the source, a relatively low fraction of the emitted nitrogen precipitates.

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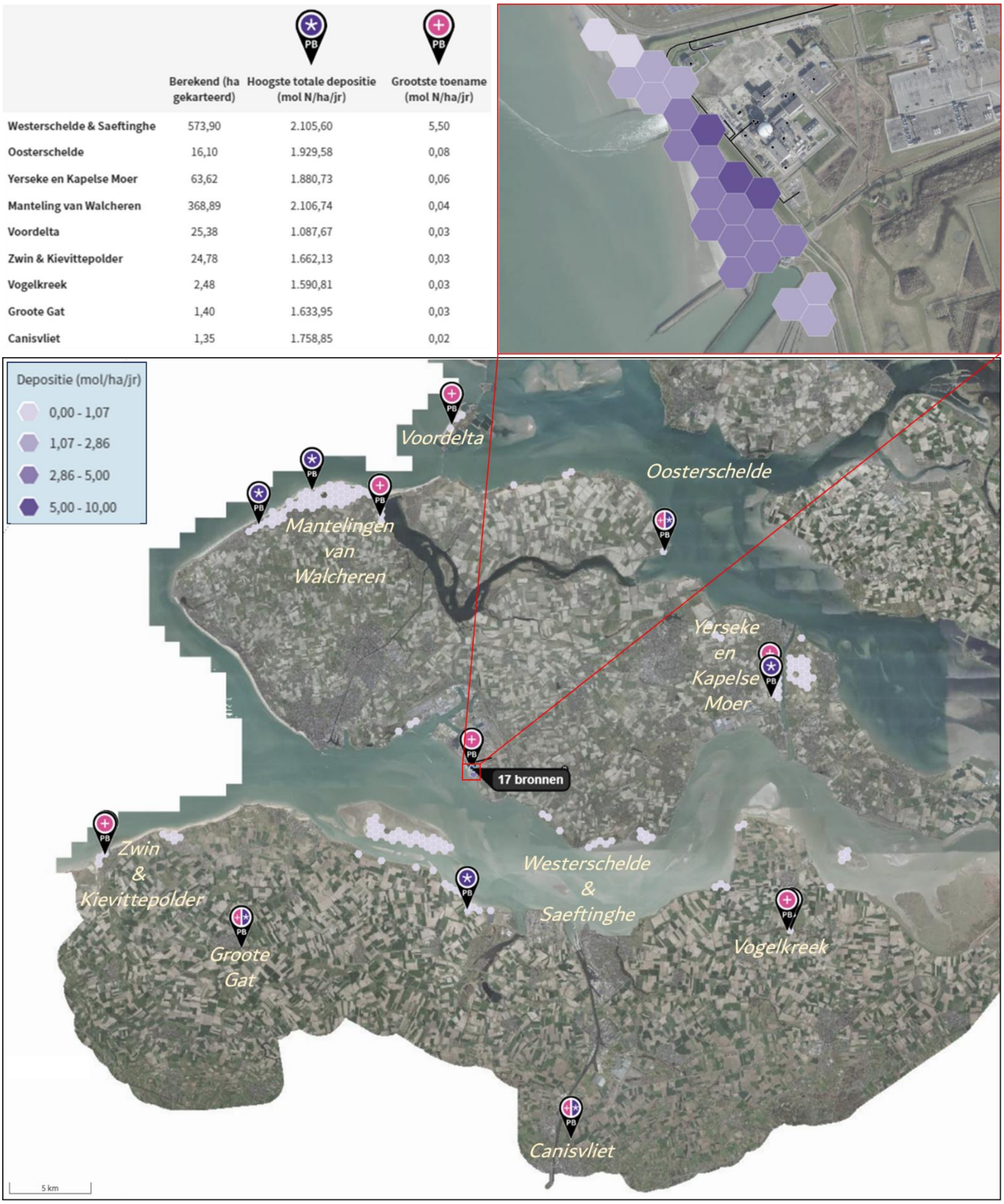
[32] The AERIUS Calculator is a fundamental calculation tool managed by the National Institute for Public Health and the Environment (RIVM) on behalf of the Ministry of Agriculture, Nature and Food Quality. The AERIUS Calculator is specifically designed for calculating the nitrogen deposition of activities on nitrogen-sensitive habitat types and biotopes within Natura 2000 areas. This therefore does not include any nitrogen deposition on nature outside Natura 2000 areas. Nevertheless, the AERIUS Calculator is the most adequate method for identifying the nitrogen deposition caused by the Borssele nuclear power plant.

[33] The results of the AERIUS calculation can be shown in two ways: for the 'relevant hexagons ' and the hexagons of the 'Nature Conservation Act registration set'. The 'relevant hexagons' option comprises all the hexagons within which nitrogen-sensitive habitat types and biotopes are situated, both those subject to excess loads and those that are not. The (standard) 'Nature Conservation Act registration set' option comprises only the nitrogen-sensitive habitat types and habitats in or approaching a condition of excess load. The 'relevant hexagons' option therefore provides a more complete picture of the full nitrogen deposition, which is why this option has been used as the basis for interpreting the environmental impacts. Annex 2 gives the results for the 'Nature Conservation Act registration set'; these are generated automatically.

[34] The Borssele nuclear power plant has been operational for over 50 years, and as such itself accounts for part of the existing background nitrogen deposition in the AERIUS Calculator. In effect, this means that the nitrogen deposition from the Borssele nuclear power plant has been counted twice in the AERIUS calculation: once in the background and once in the calculated scenario. This does not represent an obstacle to identifying the environmental impacts, since a good picture has been obtained of the extent of nitrogen deposition by the Borssele nuclear power plant. However, it may be an issue for EIA Phase 2.



	Berekend (ha gekarteerd)	Hoogste totale depositie (mol N/ha/jr)	Grootste toename (mol N/ha/jr)
Westerschelde & Saeftinghe	573,90	2.105,60	5,50
Oosterschelde	16,10	1.929,58	0,08
Yerseke en Kapelse Moer	63,62	1.880,73	0,06
Manteling van Walcheren	368,89	2.106,74	0,04
Voordelta	25,38	1.087,67	0,03
Zwin & Kievittepolder	24,78	1.662,13	0,03
Vogelkreek	2,48	1.590,81	0,03
Groote Gat	1,40	1.633,95	0,03
Canisvliet	1,35	1.758,85	0,02

Figure 6-5 Nitrogen deposition caused by the regular operation of the Borssele nuclear power plant, calculated using the AERIUS Calculator (version 2023.1). See Annexes 2 and 3 for more information. ***Notes: 'Calculated (hectares surveyed)'*** *= Total surface area of habitat types within that N2000 area which show an increase in deposition from the Borssele nuclear power plant.* ***'Highest total deposition (mol N/ha/yr)'*** *= Highest total deposition (background + calculated situation) on a hexagon within that N2000 area where there is deposition from the Borssele nuclear power plant.* ***'Greatest increase (mol N/ha/yr)'*** *= Highest increase in deposition as a result of the Borssele nuclear power plant on hexagons within that N2000 area*

Table 6-3 Nitrogen deposition caused by the regular operation of the Borssele nuclear power plant, calculated using the AERIUS Calculator (version 2023.1_20231207). See Annexes 2 and 3 for more information. ***Notes: 'CDV (mol/ha/yr)'*** *= Critical Deposition Value, or the boundary above which the habitat type may experience negative impacts from the nitrogen load.* ***'Total Nit. Dep. (mol N/ha/yr)'*** *= Highest total deposition (background + calculated situation) on a hexagon of the habitat type where there is deposition from the Borssele nuclear power plant.* ***'Excess load (mol/ha/yr + category)'*** *= Extent of excess load, in other words Total Nit. Dep. minus CDV. '****Max. Nit. Dep. (mol/ha/yr)'*** *= Highest deposition as a result of the Borssele nuclear power plant on the relevant hexagon of the habitat type, as explained in footnote 34.* ***'Calculated area (ha)'*** *= Total area of habitat type or biotope where there is an increase in deposition from the Borssele nuclear power plant*

Autonomous data							KCB	
Natura 2000 area	**Habitat type**		**WFD (mol/ha/yr)**	**Total Nit. Dep. (mol/ha/yr)**	**Excess load (mol/ha/yr + category)**		**Max. Nit. Dep. (mol/ha/yr)***	**Calculated surface area (ha)***
Western Scheldt & Saeftinghe	H1310A	Halophile pioneer growth (glasswort)	1,643	2,098.22	455.22	Moderate excess load	**5.50**	301.05
	H1330A	Salt meadows and halophile grassland (outside the sea dyke)	1,429	2,105.60	676.60	Moderate excess load	**5.50**	158.23
	H2120	White dunes	1,429	1,715.33	286.33	Moderate excess load	**5.15**	12.69
	H2130A	Grey dunes (lime-rich)	1,071	1,374.22	303.22	Moderate excess load	**5.15**	0.87
	H2110	Embryonic dunes	1,429	1,404.26	-24.74	Approaching excess load	**5.13**	1.13
	H1320	Spartina swards	1,643	2,098.22	455.22	Moderate excess load	**5.00**	80.77
	H2190B	Humid dune slacks (lime-rich)	1,429	2,019.93	590.93	Moderate excess load	**2.75**	1.02
	H2160	Dunes with Hippophae rhamnoides	2,000	1,671.54	-328.46	No excess load	**0.95**	13.22
	H1330B	Salt meadows and halophile grassland (within the sea dyke)	1,429	1,623.96	194.96	Moderate excess load	**0.11**	4.76
	H1310B	Halophile pioneer growth (Sagina maritima)	1,429	1,071.32	-357.68	No excess load	**0.02**	0.15
Eastern Scheldt	H1330B	Salt meadows and halophile grassland (within the sea dyke)	1,429	1,929.58	500.58	Moderate excess load	**0.08**	5.54
	H1320	Spartina swards	1,643	1,648.78	5.78	Slight excess load	**0.07**	5.69
	H1330A	Salt meadows and halophile grassland (outside the sea dyke)	1,429	1,648.78	219.78	Moderate excess load	**0.07**	1.77
	H1310A	Halophile pioneer growth (glasswort)	1,643	1,484.38	-158.62	No excess load	**0.07**	1.74
	H7210	Calcareous fens with Cladium mariscus and species of the Caricion davallianae	1,429	1,400.01	-28.99	Approaching excess load	**0.06**	0.13
	H2130A	Grey dunes (lime-rich)	1,071	1,239.78	168.78	Moderate excess load	**0.05**	1.17
	H7140B	Transition mires and quaking bogs (sphagnum reed marshes)	500	1,123.03	623.03	Moderate excess load	**0.05**	0.06
Yerseke and Kapelse Moer	H1330B	Salt meadows and halophile grassland (within the sea dyke)	1,429	1,880.73	451.73	Moderate excess load	**0.06**	52.02
	H1310A	Halophile pioneer growth (glasswort)	1,643	1,806.49	163.49	Moderate excess load	**0.05**	11.6
Manteling van Walcheren	H2130B	Grey dunes (lime-poor)	929	1,832.22	903.22	Moderate excess load	**0.04**	110.66
	H2160	Dunes with Hippophae rhamnoides	2,000	1,924.66	-75.34	No excess load	**0.04**	68.41
	H2180A	Dune forests (dry), beech/oak forest	1,071	2,106.74	1,035.74	Moderate excess load	**0.04**	59.39
	H2180C	Dune forests (inner dune fringes)	1,786	2,106.74	320.74	Moderate excess load	**0.04**	48.12
	H2180B	Dune forests (humid)	2,214	2,106.74	-107.26	No excess load	**0.04**	14.42
	H2190C	Humid dune valleys (decalcified)	1,071	1,819.81	748.81	Moderate excess load	**0.04**	2.78

Autonomous data							KCB	
Natura 2000 area	**Habitat type**		**WFD (mol/ha/yr)**	**Total Nit. Dep. (mol/ha/yr)**	**Excess load (mol/ha/yr + category)**		**Max. Nit. Dep. (mol/ha/yr)***	**Calculated surface area (ha)***
	H2130C	Grey dunes (herbaceous vegetation)	786	1,819.81	1,033.81	Moderate excess load	**0.04**	0.36
	H1330B	Salt meadows and halophile grassland (within the sea dyke)	1,429	1,400.06	-28.94	Approaching excess load	**0.04**	0.27
	H2120	White dunes	1,429	1,348.23	-80.77	No excess load	**0.03**	21.54
	H2130A	Grey dunes (lime-rich)	1,071	1,681.40	610.40	Moderate excess load	**0.03**	19.07
	H2190B	Humid dune slacks (lime-rich)	1,429	1,433.06	4.06	Slight excess load	**0.03**	13.18
	H2170	Dunes with Salix repens ssp. argentea (Salicion arenariae)	2,286	1,441.71	-844.29	No excess load	**0.03**	10.34
	H2190A	Humid dune valleys (open water)	1,000	1,433.06	433.06	Moderate excess load	**0.03**	0.35
Area offshore of the Delta	H2120	White dunes	1,429	990.34	-438.66	No excess load	**0.03**	12.91
	ZGH2110	Embryonic dunes	1,429.00	1,087.67	-341.33	No excess load	**0.03**	6.24
	ZGH2120	White dunes	1,429.00	1,087.67	-341.33	No excess load	**0.03**	6.24
Groote Gat	Lg08	Humid, moderately eutrophic grassland	1,571.00	1,633.95	62.95	Slight excess load	**0.03**	1.06
	H1330B	Salt meadows and halophile grassland (within the sea dyke)	1,429.00	1,605.39	176.39	Moderate excess load	**0.03**	0.33
Vogel kreek	Lg08	Humid, moderately eutrophic grassland	1,571.00	1,590.81	19.81	Slight excess load	**0.03**	2.48
Zwin & Kievittepolder	H2160	Dunes with Hippophae rhamnoides	2,000.00	1,662.13	-337.87	No excess load	**0.03**	12.94
	H2180C	Dune forests (inner dune fringes)	1,786.00	1,662.13	-123.87	No excess load	**0.03**	2.47
	H1330A	Salt meadows and halophile grassland (outside the sea dyke)	1,429.00	1,458.86	29.86	Slight excess load	**0.02**	4.06
	H2120	White dunes	1,429.00	1,528.65	99.65	Moderate excess load	**0.02**	2.25
	H1330B	Salt meadows and halophile grassland (within the sea dyke)	1,429.00	1,437.37	8.37	Slight excess load	**0.02**	1.92
	H2190B	Humid dune slacks (lime-rich)	1,429.00	1,266.39	-162.61	No excess load	**0.02**	0.57
	H2180B	Dune forests (humid)	2,214.00	1,333.13	-880.87	No excess load	**0.02**	0.29
	H2190A	Humid dune valleys (open water)	1,000.00	1,416.39	416.39	Moderate excess load	**0.02**	0.2
	H1310A	Halophile pioneer growth (glasswort)	1,643.00	1,431.51	-211.49	No excess load	**0.02**	0.05
	H2130A	Grey dunes (lime-rich)	1,071.00	1,146.00	75.00	Moderate excess load	**0.02**	0.02
	H1320	Spartina swards	1,643.00	1,154.60	-488.40	No excess load	**0.02**	0.01
Canisvliet	Lg08	Humid, moderately eutrophic grassland	1,571.00	1,758.85	187.85	Moderate excess load	**0.02**	1.35

** The maximum nitrogen deposition (Max. Nit. Dep.) is not applicable to the entire calculated (total) area but only describes the deposition on the relevant hexagon that receives the maximum deposition from the Borssele nuclear power plant. In many cases, the average deposition over the entire calculated (total) area is therefore significantly lower than the maximum deposition*

6.3.6.3 Intersections with the ecological framework

The nitrogen deposition caused by the Borssele nuclear power plant can result in environmental impacts for habitat types and biotopes. As a result, specific species of plants and animals can also be directly or indirectly affected. This falls outside the scope of EIA Phase 1, but does represent an issue requiring attention for EIA Phase 2. In EIA Phase 1, we examine the environmental impacts on habitats and management types. The environmental impacts as a result of nitrogen deposition by the Borssele nuclear power plant are therefore related to the following aspects of the ecological framework:

- Natura 2000
  - Habitat types: Quality of nitrogen-sensitive habitat types.
- NNN
  - Nitrogen-sensitive management types within the NNZ area: Essential characteristics and qualities.

6.3.7 Intersections with criteria and ecological framework

An overview of the intersections between the criteria and elements of the ecological framework is provided in Table 6-4.

Table 6-4 Intersections between the consequences of the proposed activity and aspects of the ecological framework. HD = Habitats Directive, WBD = Wild Birds Directive, n/a = criterion does not intersect with the relevant component of the ecological framework

Framework / Criterion	N2000	NNZ	Flora & Fauna	WFD
Extraction & discharge of cooling water	Habitat types (quality) HD: Migratory fish HD: Marine mammals WBD: Various species of birds	n/a	Migratory fish (whitefish and sturgeon)	Phytoplankton Macrofauna (as zooplankton) Fish
Disturbance and damage/harm	HD: Common en grey seal WBD: Various species of birds	Surrounding NNZ area (essential characteristics and qualities)	Flora Birds Bats Land-based mammals Marine mammals Amphibians	n/a
Turbidity and sedimentation	Habitat types (quality) HD: Migratory fish HD: Marine mammals WBD: Various species of birds that hunt for fish and macrofauna by sight	n/a	Migratory fish (whitefish and sturgeon) Various species of birds that hunt for fish and macrofauna by sight	Phytoplankton Other water flora Macrofauna Fish
Pollution	Habitat types (quality) HD: Migratory fish HD: Marine mammals WBD: Various species of birds	n/a	Migratory fish (whitefish and sturgeon) Birds	Phytoplankton Other water flora Macrofauna Fish
Radiology	n/a	n/a	n/a	n/a
Nitrogen deposition	Nitrogen-sensitive habitat types (quality)	• Nitrogen-sensitive management types	n/a	n/a

6.4 Description of current ecological situation

In order to be able to provide a better assessment of the environmental impacts of the Borssele nuclear power plant, we review the current ecological situation around the plant in a relatively concise manner. The ‘current ecological situation’ is defined as the situation today, i.e. up to and including the time of writing of this report (early 2024). We also take into account the developments and trends over the past decade and decades, depending on the data available.

Following an explanation of the methodology used in Section 6.4.1, we provide a summary overview of the findings regarding the current situation in Section 6.4.2. In the subsequent sections, the situations of each biotic community are described in more detail.

6.4.1 Method

The nuclear power plant is located in a large transitional zone between freshwater and salt water and between land and water. As such, the nature around the Borssele nuclear power plant is home to a great diversity of habitats and biotic communities. Consequently, describing the current situation of the nature in this area is a complex task. In order to reflect the coherence of the estuarine ecosystem, we have chosen to discuss the most important biotic communities for the estuary from the bottom to the top of the food chain. They are: phytoplankton, zooplankton, vegetation, macrofauna, fish, birds and marine mammals. These biotic communities also intersect significantly with the ecological frameworks and criteria discussed in Sections 6.2 and 6.3. Fewer environmental impacts are anticipated for groups of species that intersect with the activities of the Borssele nuclear power plant only to a limited extent, such as bats, amphibians and flora on land; (see also Table 6-4). It has therefore been decided not to highlight the current situation of those species groups.

The level of detail of the descriptions of the current ecological situation is in line with the g oal of this chapter on ecology: to gain a broad insight into the potential environmental impacts of the Borssele nuclear power plant. For this purpose, a description at the level of biotic communities or species groups suffices. The quality and size of hab itats and biotopes are integral to the quality and size of the estuarine biotic communities. By investigating the situation of the biotic communities, we therefore also (indirectly) sketch a picture of the situation of the habitats and biotopes they use. For this reason, we do not explicitly discuss habitats and biotopes. Table 6-3 has already made clear that many habitats are in a situation of excess nitrogen load.

The most important source of information used to evidence the ecological situation is the T2021 analysis and evaluation report on the Scheldt estuary, published in December 2023 (Flemish-Dutch Scheldt Commission, 2023a, 2023b). The report represents a valuable source of information on the Scheldt estuary and discusses both biotic and abiotic factors in great detail. It also sheds light on developments over the past decade and decades. As such, it provides the foundation for the consideration of the current ecological situation in the present report. In order to keep the information in this report manageable, an outline summary has been provided; for more detailed information, we refer the reader to the T2021 report.

In the T2021 report, the Scheldt is divided into multiple sections (Figure 6-6), which the authors often treat separately. In this EIA, we have focused on the relevant zones around the Borssele nuclear power plant, i.e. the river mouth zone and the strongly and weakly polyhaline zone of the Western Scheldt.

Alongside the T2021 report, we have used the most recent WFD assessments of the biological quality elements of the surrounding WFD national water bodies (Western Scheldt, Zeeland coast) (based on publicly accessible information from *https://waterinfo-extra.rws.nl/rapportages/internationale-rapportages/krw-oordelen-rijkswaterstaat/*). These WFD assessments also provide a good insight into the condition of the relevant biotic communities over the past approximately ten years.

Discussing those biotic communities in relation to the information cited reveals the most important aspects of the ecosystem and provides a good picture of the overall current ecological situation around the Borssele nuclear power plant.

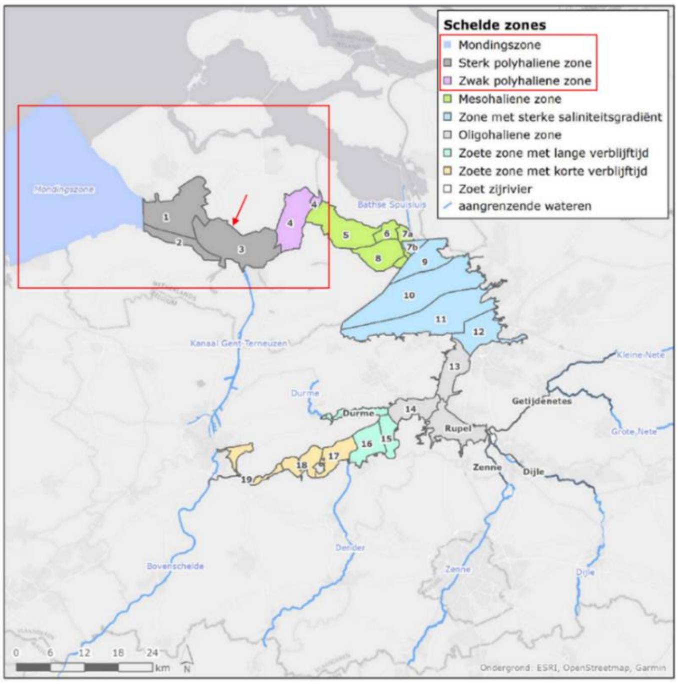


Figure 6-6 The T2021 report on the Scheldt estuary discusses all the zones highlighted in the above map. In the present report, we primarily focus on the zones around the Borssele nuclear power plant (the location of the Borssele nuclear power plant is indicated by the arrow), i.e. the river mouth zone and the strongly and weakly polyhaline zone (outlined in red). Figure from the Flemish-Dutch Scheldt Commission (2023a)

6.4.2 Summary overview

In Table 6-5 below, we summarise the current situation of the biotic communities discussed. In describing those situations, we distinguish between the following categories: predominantly good, predominantly poor, variable (large variation within the biotic community and/or a fluctuating pattern over recent history) or unclear (too little data).

Table 6-5 provides an overall picture: the current situation regarding the ecological values around the Borssele nuclear power plant is highly variable. For this reason, the assumption in EIA Phase 1 is that the situation of the biotic communities is not predominantly good, and has both negative and positive aspects. The situation of biotopes and habitat types which these biotic communities use is therefore also regarded as variable.

Table 6-5 Summary of the current situation of the biotic communities discussed

Biotic community	Current situation	Brief explanation
Phytoplankton	Variable	Variable situation because there are both positive and negative points. For instance, eutrophication and flourishing of cyanobacteria appear to be limited (positive). On the other hand, an undesirable invasive species does often occur above the desired level, and over the past decade there has been some algal bloom several times (negative). Added to that is the fact that not all the required information is available.
Zooplankton	Unclear	A very limited quantity of information is available on the zooplankton community in the Western Scheldt. The current situation cannot be clearly determined as a result.
Vegetation (water and coastal)	Variable	Variable situation because there are both positive and negative points. For instance, there is barely any seagrass still present and the vegetation zones of salt meadows display unnatural proportions in terms of their composition (negative). On the other hand, there has been a gradual improvement in area covered and quality over recent decades.
Macrofauna	Variable	Variable situation because there are both positive and negative points. Biomass, density, species richness and species diversity are predominantly good in both the littoral and sublittoral zones, and display a positive trend. The number of invasive exotic species is relatively very high, however, and the key species cockle is not present in sufficient biomasses. The situation of the key species mussel is unknown.

Biotic community	Current situation	Brief explanation
Fish	Variable	Variable situation because there are both positive and negative points. The trends vary between different functional groups of fish species and between different zones of the Western Scheldt. The strongly and weakly polyhaline zone (where the Borssele nuclear power plant is located) is rated positively for biomass but negatively for diversity.For all zones, the biomass of diadromous species (migratory fish) is limited. The species that provide a barometer of good water quality, smelt and twait shad, display a falling and rising trend, respectively. Historically, huge quantities of herring were periodically caught but these catches have fallen sharply in recent years. The current situation of the Western Scheldt as a 'nursery' for young fish is unclear.
Birds	Variable	Variable situation because there are both positive and negative points. The situation of more than half of the species of breeding birds identified is negative. This is partly attributable to the unnatural proportions between different vegetation zones in salt meadows. A positive point is that the available area of suitable breeding habitat for breeding birds has increased as a result of (local) restoration and management measures. The situation of more than half of the species of non-breeding birds identified is also negative. In particular, the number of herbivores and benthivores is falling. Causes cited are insufficient availability of food and rest, but also external causes.
Marine mammals	Predominantly good	The trend in the populations of common and grey seals is positive in both cases. The number of common and grey seals in the Western Scheldt has grown very substantially since 2000. The proportion of common seal pups is also well above the critical level of 9%. There is, however, some concern about possible impact of bioaccumulation of contaminants on the health of these apex predators.

6.4.3 Phytoplankton

Phytoplankton forms the basis of an ecosystem: via photosynthesis, it converts organic material and nutrients into biomass, which is then used as energy for the entire food chain. In the Scheldt estuary, algae play an important role in the primary production. We can differentiate between phytoplankton (algae in the water column) and phytobenthos (algae on the waterbed). The presence of phytoplankton is strongly influenced by the availability of nutrients and the predominant light climate (i.e. the turbidity of the water). Other abiotic and biotic factors can also strongly influence the phytoplankton community.

The current situation of phytoplankton is revealed by both the T2021 report on the Scheldt and the WFD assessments. This is discussed separately, after which the current situation is summarised as a whole.

6.4.3.1 T2021 report on the Scheldt estuary

The T2021 report determines the situation of phytoplankton based on various complex parameters. These include parameters that are indicative for the productivity of the phytoplankton present, concentrations of undesirable species and cyanobacteria, and parameters that are indicative of the extent to which phytoplankton are grazed and the extent of organic enrichment. Due to the complexity involved, we do not address this explicitly. The reader is instead referred to the T2021 report on the Scheldt estuary. The data which is available for parts of the Western Scheldt that are relevant for the Borssele nuclear power plant display both positive and negative signs. For instance, the concentration of *Phaeocystis*, an undesirable species, is often above the level at which detrimental impacts to the ecosystem can occur. Cyanobacteria are present well below the maximum level. This is positive. The various phytoplankton indices also provide an indication for normal values of organic matter, and thus the absence of eutrophication.

In conclusion, the situation of the phytoplankton community cannot be summarised in a single finding. There are both positive and negative points. It should be added that not all the required information is available.

6.4.3.2 WFD assessment

Phytoplankton are also defined as a biological quality element under the WFD. Figure 6-7 shows the situation of the 'phytoplankton' quality element for the WFD water body Western Scheldt and Zeeland coast (coastal water). The WFD assessments show that the algal concentration in phytoplankton in the waters around the Borssele nuclear power plant is generally at a healthy level, but that several outliers indicating higher concentrations of phytoplankton (algal bloom, i.e. worse scores) also occur. The outliers indicating higher phytoplankton concentrations may be caused by various abiotic factors. One of them is eutrophication (excess nutrients), for example caused by fertiliser run-off. Algal bloom can also occur if there is high transparency of the water and/or unusually high temperatures, which may be the case in years with low discharge from the Scheldt.

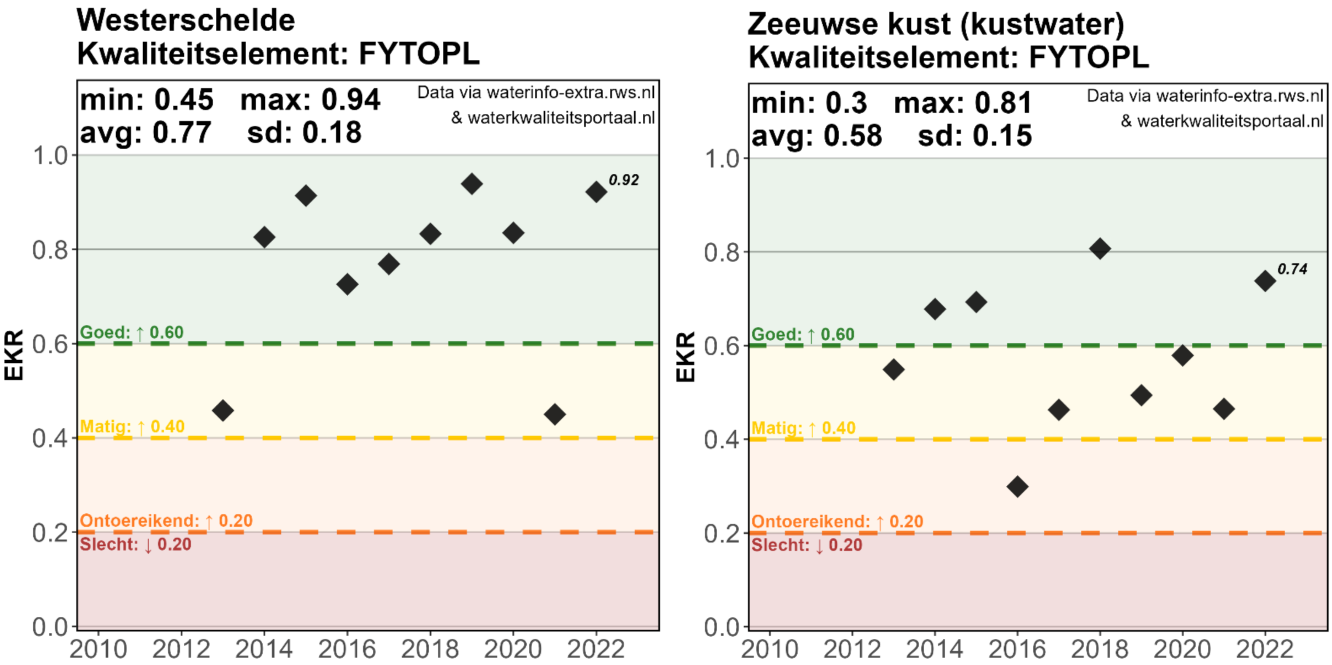


Figure 6-7 The situation (in EQR score) of the 'phytoplankton' quality element over time in the WFD water body Western Scheldt (left) and the more westerly WFD water body Zeeland coast (coastal water) (right)

6.4.3.3 Summary of the current situation

The T2021 report on the Scheldt estuary and the WFD assessment both show that the current situation of phytoplankton in the Western Scheldt is variable. The phytoplankton community is strongly influenced by abiotic and biotic factors. Due to the complexity of the interactions, it is not (yet) always possible to fully understand the situation.

6.4.4 Zooplankton

Zooplankton is a collective term for small organisms which are suspended in the water column and feed on other small organisms (phytoplankton, bacteria and/or other species of zooplankton) or detritus. They therefore differ from phytoplankton in that the organisms consume and do not produce. The zooplankton community comprises species/species groups that remain very small throughout their lives, such as copepods and rotifers, but it also comprises young life stages of species/species groups that later grow larger, such as shellfish, crustaceans, polychaetes and fish.

Zooplankton are not considered within the WFD; the T2021 report on the Scheldt estuary does consider this group. However, most of the data in the T2021 report is for the zooplankton community in the upstream parts of the Scheldt estuary. It reveals that the current situation of zooplankton in the Zeeschelde (the Belgian part of the river basin) is predominantly poor. A very limited amount of data is available for the Western Scheldt and the river mouth.A further issue is that zooplankton as a group are not directly protected under statutory frameworks. Based on the available data, it is not possible to provide a clear picture of the current situation. The situation of zooplankton therefore remains unclear and has been identified as a knowledge gap.

6.4.5 Vegetation

By vegetation we mean the macrophytes (higher plants). These include the plants that grow in the saline to brackish intertidal zone. In the south-western Delta, these are known as 'schorren' (salt meadows). Sea grasses are also macrophytes; they grow lower down in the intertidal zone. However, sea grasses barely occur in the Scheldt any longer; as a consequence, this group was left out of consideration in the T2021 report on the Scheldt estuary. Sea grasses are, however, part of the WFD assessment.

Vegetation on the salt meadows provides an important source of food for herbivorous birds and to a lesser extent for omnivorous birds. Other bird groups use the low salt meadows primarily to roost during high tide. The salt meadows are also used as a breeding habitat by many species of (coastal) breeding birds. Within salt meadows, different vegetation zones are differentiated which need to be in equilibrium with one another in order to be able to perform their ecological functions properly. As such, the situation of the vegetation is indicative of the health of the ecosystem.

6.4.5.1 T2021 report on the Scheldt estuary

The area of salt meadows has been gradually increasing since 1993 (Figure 6-8). In the Western Scheldt, over 2300 hectares of salt meadows are present east of Hansweert. West of Hansweert (the Borssele side), there are slightly less than 500 hectares of salt meadows. This is around or slightly above the target values. The relationship between the vegetation zones of the salt meadows in the Western Scheldt is, however, 'rather skewed' (Figure 6-9). The 'high-level salt meadow' and 'low-level salt meadow' zones dominate the bulk of the area in question; 'pioneer' and 'medium-level salt meadow' are barely present. As a result of the unequal distribution of vegetation zones, the quality of the salt meadows is limited. However, their quality has been gradually increasing again since 1993. That is to say that the proportions between the vegetation zones have been improving over the years.

There are also several invasive exotic species within the vegetation community of the Western Scheldt. The number of species is stable over time, but the area covered by invasive exotic species is increasing. This is regarded as negative.

According to the T2021 report, the most important causes underlying this predominantly poor situation of salt meadows are: the deepening of the main channels, a reduction in natural dynamism in the intertidal zone, increased high water levels, reduced salinity, and encroachment. These causes mean that there is less scope for natural cyclical processes (such as erosion and sedimentation) in the intertidal zone, which is, however, essential for the dynamic equilibrium of salt meadows.

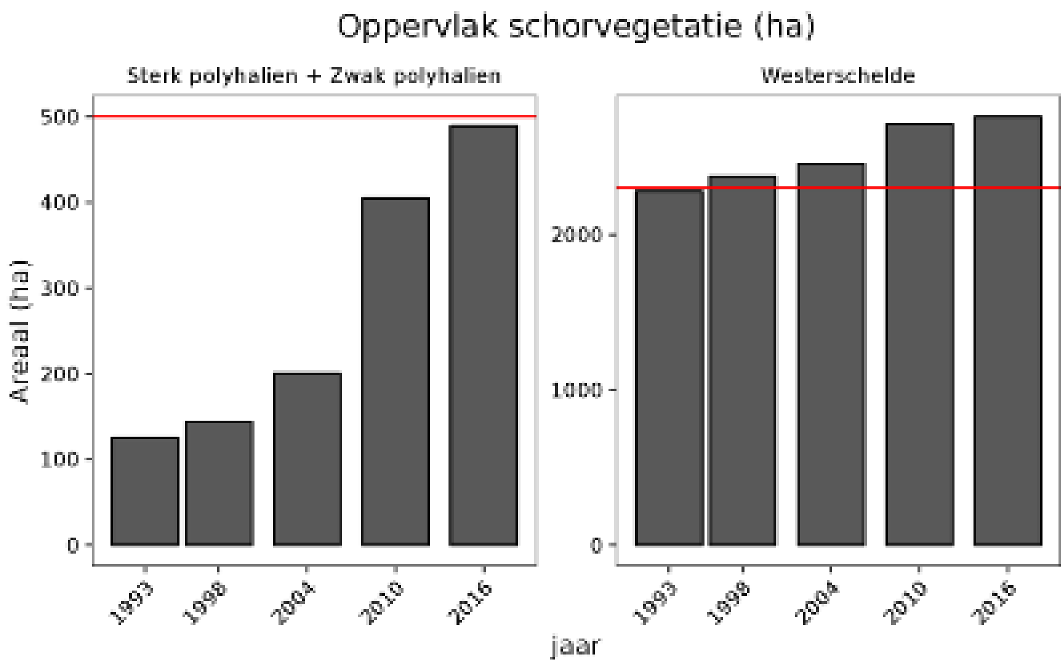


Figure 6-8 Area of salt meadow vegetation in the western part of the Western Scheldt (left) and in the Western Scheldt as a whole. The red line shows the lower limit for a positive evaluation. Image from Flemish-Dutch Scheldt Commission (2023a)

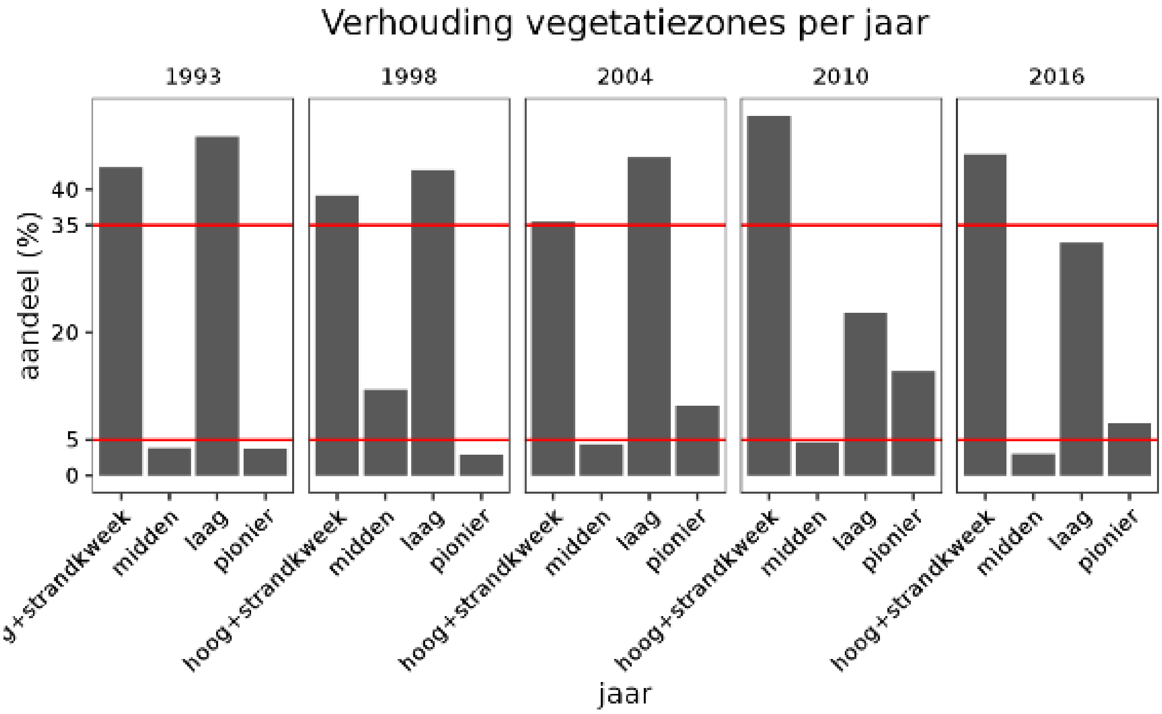


Figure 6-9 Relationship between vegetation zones in the Western Scheldt in the five years surveyed. The red lines indicate the limits for a positive evaluation; each zone that lies within those limits scores one point for quality. Image from Flemish-Dutch Scheldt Commission (2023a)

6.4.5.2 WFD assessment

Vegetation in the form of 'other water flora' (all plants except phytoplankton) is also defined as a biological quality element under the WFD.The 'other water flora' group comprises both salt meadow vegetation and sea grasses. Figure 6-10 shows the situation of the 'other water flora' quality element over time in the Western Scheldt WFD water body, including the underlying scores at aspect level. The 'other water flora' quality element is not applicable in the adjacent Zeeland coast WFD water body, which means no information is available.

What is immediately noticeable is the fact that the lower limit for the class 'good' is an EQR score of 0.20, instead of the standard lower limit of 0.60. The limit has therefore been revised downwards substantially. This is only permitted if the standard limit of 0.60 is not considered reasonably achievable in the current autonomous situation. This is usually a result of circumstances caused by human intervention (loss of habitat, dykes, dams, canalisation, etc.).

The condition of other water flora fluctuates around just below the downwardly revised lower limit of 0.20. The sub-benchmark scores (Figure 6-10 on the right) show that the relatively low EQR score is primarily attributable to the poor condition of seagrass. The area of seagrass has been consistently rated 0 over the years, and the quality of seagrass is also very poor. Although the area covered by salt meadows is rated 'good', the quality of the salt meadows is rated 'poor'.

The limited EQR score for 'other water flora' is also attributable to the causes listed in the previous section on the T2021 analysis.

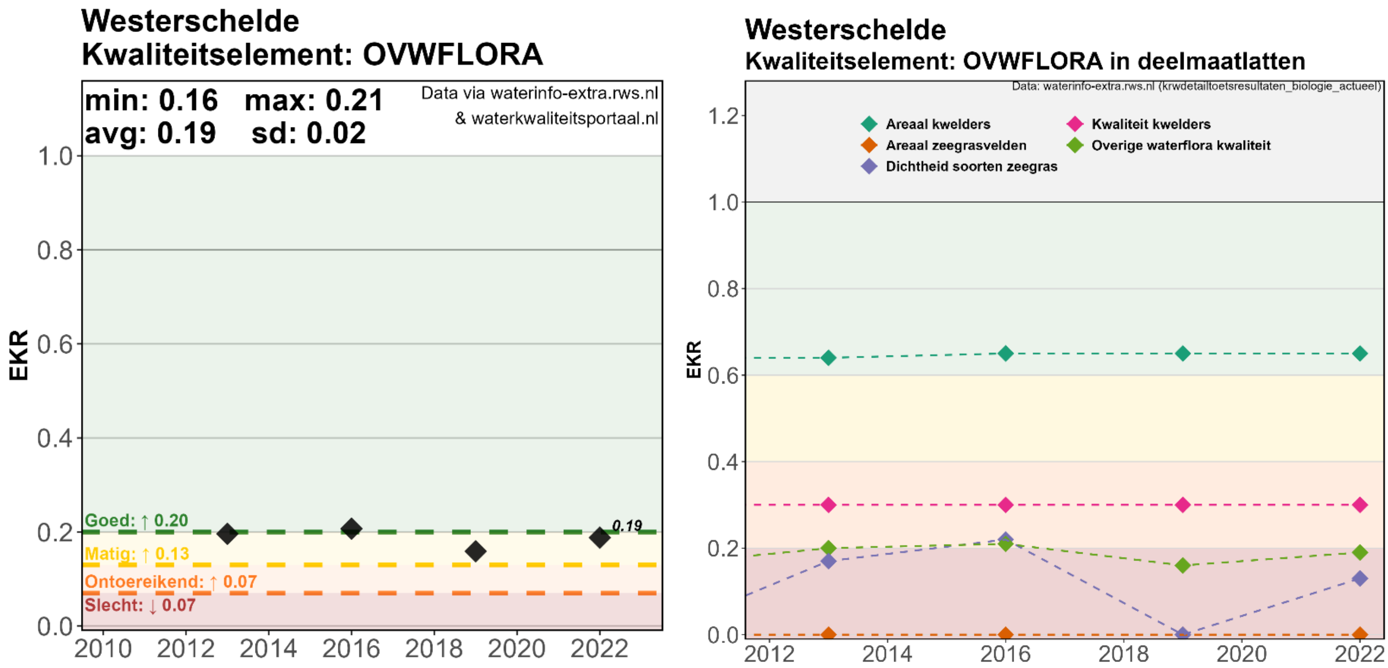


Figure 6-10 Left: The situation (in EQR score) of the 'other water flora' quality element in the WFD water body Western Scheldt over time. Right: the underlying detail scores for the 'other water flora' quality element in sub-benchmarks

6.4.5.3 Summary of the current situation

The T2021 report on the Scheldt estuary and the WFD assessment both show that the current situation of vegetation in the Western Scheldt is variable. There are elements that score relatively well, while the situation of other elements is clearly substandard. This is primarily due to the weakness of necessary natural cyclical processes in the intertidal zone. The final assessment on the situation of vegetation is therefore that it is variable.

6.4.6 Macrofauna

The group of macrofauna consists of organisms that live in or on the water bed and are visible to the naked eye (larger than 1 mm), such as worms, shellfish, snails and crustaceans. They play an important role in the ecosystem: they help in breaking down dead organic material, making it available again in the food chain. This makes macrofauna an essential food source for higher trophic levels, such as fish and birds. Finally, they play a role in the bottom structure – for instance, shellfish banks serve as a habitat in themselves and provide aeration of the bottom, making nutrients more available to plants. As such, the situation of macrofauna is indicative of the functioning of the ecosystem.

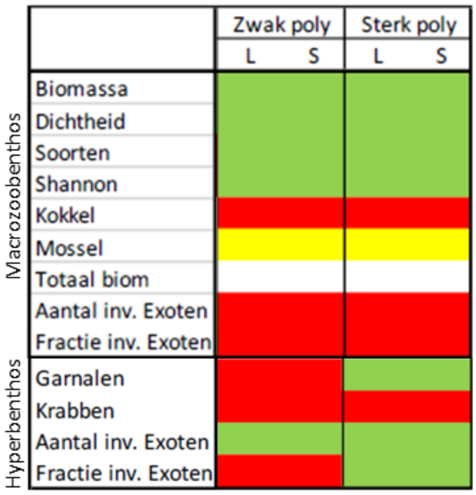
Because macrofauna make up an important link in the aquatic ecosystem, the group is included in both the T2021 report and the WFD assessments.

6.4.6.1 T2021 report on the Scheldt estuary

The situation of macrofauna is in many respects positive in the strongly and weakly polyhaline zone of the Western Scheldt which is relevant for the Borssele nuclear power plant (the river mouth has not been assessed). This is summarised in Table 6-6. The underlying information for the table reveals positive trends over time in biomass, density, species richness and species diversity in both the littoral (intertidal) and the sublittoral (permanently flooded) zones. For this reason, the rating given is positive. See also the positive trend in biomass, which has tripled in a relatively short space of time. (Figure 6-11 on the left). In the T2021 evaluation report, the positive developments in these parameters are linked to factors including the reduction in compounds of tributyltin (TBT), a very harmful substance to bivalves, over recent decades. A further factor is the increase in (invasive) exotic species in the Western Scheldt over recent decades (Figure 6-11 on the right). This has had a positive effect on biomasses and densities, but is regarded as negative in view of the fact that they outcompete native species.

The cockle and mussel are also considered separately in view of their key role in the ecosystem. These species are essential for both lower and higher trophic levels and as such provide a good indicator of the capacity and ecological functioning of the Western Scheldt. Too little data is available for mussels to draw any conclusions about their situation. The situation of cockles is negative, given the fact that the biomass of the cockle population is too low. This may be connected with long hot periods in the summer leading to large-scale mortality. The cockle biomass has, however, displayed a cautious recovery since approximately 2015.

Table 6-6 Overview of the final scores from the T2021 analysis report per calculation parameter for macrozoobenthos (all macrofauna with the exception of more mobile species above the water bed, such as crustaceans) and hyperbenthos (the more mobile species above the water bed) in the strongly and weakly polyhaline zone of the Western Scheldt that is relevant for the Borssele nuclear power plant (the river mouth has not been assessed). 'Shannon' is a measure of species diversity. Green = positive assessment, red = negative assessment, yellow = insufficient data. L = littoral and S = sublittoral. Table from Flemish-Dutch Scheldt Commission (2023a)



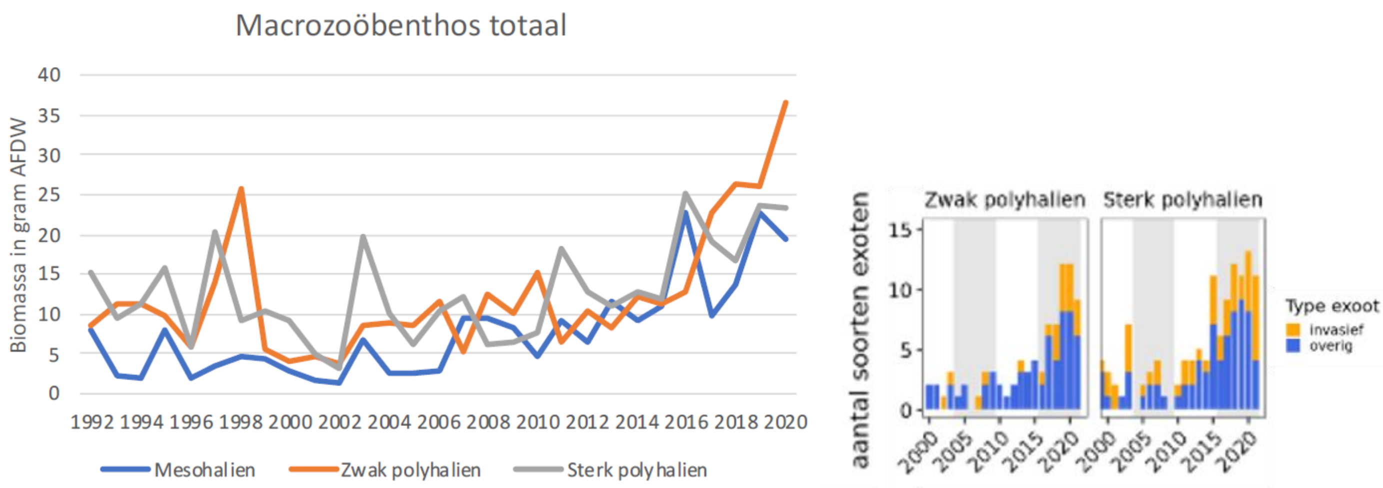


Figure 6-11 Left: The biomass of macrozoobenthos (in grams of ash-free dry weight/m²) over time in the zones of the Western Scheldt which are relevant for the Borssele nuclear power plant. Right: The number of (invasive) exotic species within the macrofauna group over time in the zones of the Western Scheldt which are relevant for the Borssele nuclear power plant. Images from Flemish-Dutch Scheldt Commission (2023a)

6.4.6.2 WFD assessment

Macrofauna as a group are also defined as a biological quality element under the WFD. Figure 6-12 shows the situation of the 'macrofauna' quality element over the years for the WFD water body Western Scheldt and Zeeland coast (coastal water). The lower limit for the class 'good' is the standard EQR score of 0.60. This is a positive sign, since it means that the current autonomous conditions do not provide any reason to revise this boundary downwards. The condition of both water bodies is consistently around the boundary value for the condition 'good'. At a few points in time, the condition is just 'moderate'.

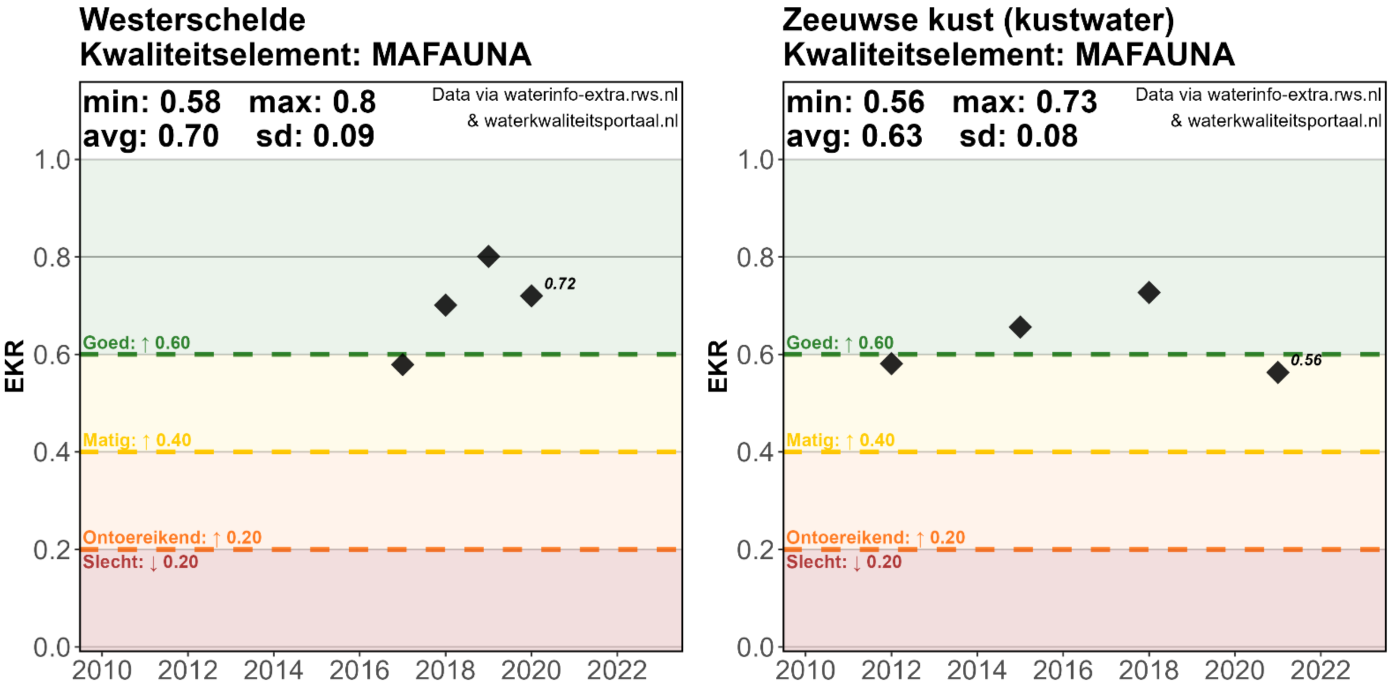


Figure 6-12 The situation (in EQR score) of the 'macrofauna' quality element over time in the WFD water body Western Scheldt (left) and the more westerly WFD water body Zeeland coast (coastal water) (right)

6.4.6.3 Summary of the current situation

The T2021 report on the Scheldt estuary and the WFD assessment both show that the situation of macrofauna has positive elements, with positive trends visible in biomass, density, species richness and species diversity. In many respects, the condition is relatively good. At the same time, there are also aspects which are less positive, for example in relation to the large proportion of invasive exotic species, which compete with native species. The final assessment on the situation of macrofauna is therefore that it is variable.

6.4.7 Fish

The fish community plays a crucial role within the food web of the Scheldt estuary. A natural estuary is characterised by a large diversity due to the transition from freshwater to salt water. In addition, the shallow, low-dynamic parts of the estuary in particular perform an important function as a hatchery and nursery for a large number of fish species. Fish stocks are one factor which determines the estuary's capacity to support numerous fish-eating species, such as the sea mammals common seal and harbour porpoise, but also birds such as the Sandwich tern, common tern and great crested grebe. As such, the situation of fish is indicative of the healthy functioning of the ecosystem.

Because fish make up an important link in the aquatic ecosystem, the group is included in both the T2021 report and the WFD assessments.

6.4.7.1 T2021

In the Western Scheldt (weakly and strongly polyhaline and mesohaline zone), the trends and functional groups are relatively unclear and incoherent. Nevertheless, biomass and diversity are predominantly rated negatively. In particular the mesohaline (eastern) zone within the Western Scheldt is rated negatively. The highly and weakly polyhaline zones (where the Borssele nuclear power plant is located) are rated positively for biomass but negatively for diversity.For all zones, the biomass of diadromous species is limited. The diadromous species group also comprises the migratory fish species which enjoy species protection under N2000 and FF. Due to the different trends for separately assessed key species (species that provide a barometer of the ecological functioning of the system), evaluating the nursery function of the Western Scheldt is not a straightforward matter. For instance, species that indicate good water quality, smelt and twait shad, display falling and rising trends, respectively. The biomass of eels is falling, whereas that of herring is increasing. It is worth noting that historically, huge quantities of herring were periodically caught, but these catches have fallen sharply in recent years.

Factors that may underlie the current situation of the fish community are, on the one hand, positive. For instance, despite the general rise in water temperature, the oxygen balance is improving. This is positive given the fact that many estuarine fish species are vulnerable to low concentrations of dissolved oxygen. The T2021 report therefore concludes that the observed temperature rise 'may' currently not be a problem for the fish community. The low-dynamic littoral zone has also increased, which means more and better rearing habitats for young fish. Finally, transparency in the Western Scheldt is predominantly low; this is a fairly constant factor. For the nursery function of the Western Scheldt, reduced visibility would offer better rearing opportunities, because less energy would need to be expended on avoiding fish-eating predators and more on feeding.

The T2021 report concludes the subject of fish by stating that the findings for fish are associated with a high degree of uncertainty due to the complex whole of potential interactions.

6.4.7.2 WFD assessment

Fish as a group are also defined as a biological quality element under the WFD. Figure 6-13 shows the situation of the 'fish' quality element over time in the WFD water body Western Scheldt, including the underlying scores at aspect level. What is immediately noticeable is the fact that the lower limit for the 'good' class is an EQR score of 0.37, instead of the standard lower limit of 0.60 based on the natural reference. The limit has therefore been revised downwards. This is only permitted if the standard limit of 0.60 is not considered reasonably achievable in the current autonomous situation. This is usually a result of poor conditions caused by human intervention.

The condition of the 'fish' quality element fluctuates around the lower limit (which has been revised downwards) for the 'good' class, but it is also regularly in the 'moderate' class. The scores at sub-benchmark level (Figure 6-13 on the right) reveal that the relatively low EQR score is primarily attributable to the poor to bad score for the 'abundance' sub-benchmark. This primarily means that the distribution in abundance between groups of fish species with similar ways of life, such as diadromous species and estuarine-resident species (see figure) is not in line with what would naturally be expected in the Western Scheldt. The quality and species composition of the fish community generally scores 'poor' to 'bad'. It should be noted that not all fish species that would naturally be expected still occur in the Western Scheldt. For instance, the natural reference for the category of diadromous species (migratory fish) is 12 species. During the WFD sampling between 2017 and 2022, the number of species within this category was limited to between two and five. Over that period, a low number of species were also observed within the categories of marine seasonal visitors and freshwater fish compared to the natural reference. The species-richness of marine juveniles and estuary-resident species is predominantly good, however.

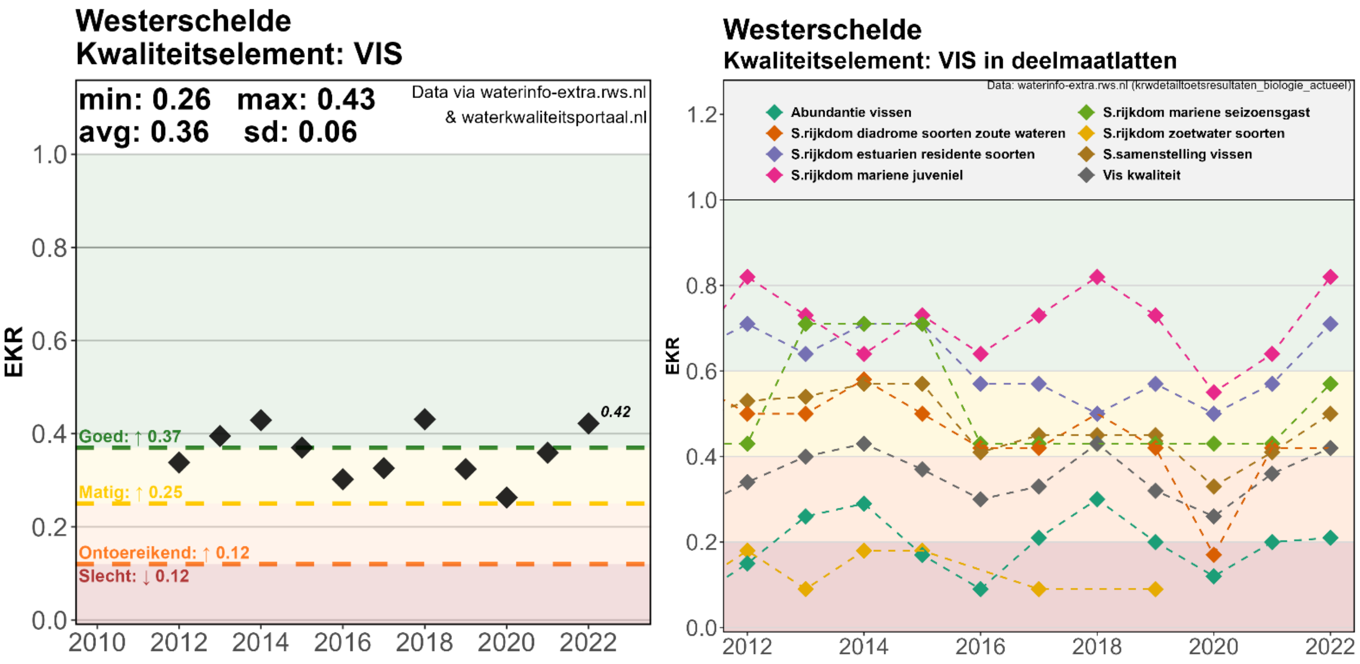


Figure 6-13 Left: The situation (in EQR score) of the 'fish' quality element over time in the WFD water body Western Scheldt. Right: The underlying detail scores for the quality element fish in sub-benchmarks

6.4.7.3 Summary of the current situation

The T2021 report on the Scheldt estuary and the WFD assessment both show that the situation of fish is variable. Certain species/species groups display positive developments, whereas the picture for other species/species groups is less encouraging. For many species groups, fewer species occur than would be expected for a natural estuary.

6.4.8 Birds

As stated above, estuaries are naturally diverse and eutrophic. Partly as a result, the Western Scheldt represents a crucial habitat and breeding ground for migratory and wintering birds, including ducks, geese, waders and typical coastal breeding birds. These species are adapted to life in highly dynamic environments, where there are generally few ground predators. Many species are dependent on the Scheldt estuary for part or even the whole of the year. Birds are regarded as important indicators of the functioning of an ecosystem. It is important to look beyond purely local developments, given the fact that many species migrate for thousands of kilometres.

Birds are not considered under the WFD; the T2021 report on the Scheldt estuary does consider this group. The condition of birds is discussed separately for breeding and non-breeding birds (winterers and passing migrants).

6.4.8.1 Breeding birds

The T2021 report reveals that many species of breeding birds are in decline, and are therefore rated negatively (Table 6-7). This is partly because the evaluation is limited to the level of the Scheldt estuary. Due to the mobile character of coastal breeding birds, a better picture can be obtained by considering the entire south-western Delta. This yields a more positive picture, but the situation of more than half of the species remains negative (Table 6-8).

Many coastal breeding birds are bound to the specific developmental stages of the salt meadow vegetation, as discussed in Section 6.4.5.1. Those species that specialise in breeding on the virtually bare zone of pioneer growth, such as little tern, common tern and Kentish plover, are predominantly faring poorly. These species are suffering from a reduction in dynamism and associated vegetation succession (encroachment) and ground predation (in particular from foxes), but also from a changing food supply. As also demonstrated in Figure 6-9 of Section 6.4.5.1, the pioneer zone makes up a small fraction of the salt meadow vegetation.

A positive point is that in recent decades, the available area of suitable breeding habitat for coastal breeding birds has increased as a result of (local) restoration and management measures. An example is the creation of the Waterdunen area ('water dunes') near Breskens. In the initial years since their creation, the water dunes have had a positive impact on the numbers of coastal breeding birds in and near the Western Scheldt. Local protection measures for breeding birds are also bearing fruit. An example is the erection of fencing and the provision of public information around nests of breeding Kentish plovers. Such measures partially compensate for the negative pressure factors, such as disturbance caused by recreation and an insufficient food supply, but not completely. Aside from local issues, external issues also play an important role, such as the changing of migration behaviour as a result of climate change, diseases (bird flu) or unfavourable conditions in biotopes abroad.

Table 6-7 Comparison of the numbers of identified breeding bird species within the limits of the Western Scheldt & Saeftinghe Natura 2000 area with the conservation objectives/minimum target numbers set out in the Management Plan. Numbers between brackets relate to incomplete counts. Green = positive evaluation and red = negative evaluation. Numbers from Sovon (Dutch Centre for Field Ornithology), table from Flemish-Dutch Scheldt Commission (2023a)

Soort	ihd	2016	2017	2018	2019	2020	2021	beoordeling
Blauwborst	450	?	[340]	?	?	?	?	
Bontbekplevier	28	14	19	8	9	5	7	
Bruine kiekendief	20	[23]	[28]	[23]	[26]	[26]	[24]	
Dwergstern	226	181	108	0	24	5	75	
Grote stern	3.866	2.472	2.045	2.151	2.650	3.450	110	
Kluut	203	198	200	104	194	92	98	
Strandplevier	23	19	14	9	24	19	12	
Visdief	1.410	854	652	680	408	555	636	
Zwartkopmeeuw	419	516	1.305	902	1.402	647	269	

Table 6-8 Comparison of the numbers of identified breeding bird species within the entire south-western Delta. Green = positive evaluation and red = negative evaluation. Numbers from Sovon (Dutch Centre for Field Ornithology), table from Flemish-Dutch Scheldt Commission (2023a)

		Natura 2000 ruime begrenzing						
Soort	ihd	2016	2017	2018	2019	2020	2021	beoordeling
Bontbekplevier	28	23	28	16	18	17	17	
Dwergstern	226	182	108	48	34	100	216	
Grote stern	3.866	2.472	2.045	2.151	2.650	3.465	4.960	
Kluut	203	272	286	291	300	265	310	
Strandplevier	23	24	24	23	30	29	18	
Visdief	1.410	1.099	1.199	1.382	1.052	1.039	1.239	
Zwartkopmeeuw	419	646	1.758	926	1.565	1.055	3.512	

6.4.8.2 Non-breeding birds

The T2021 report rates over half of the species of non-breeding birds negatively (Table 6-9). This is in line with the pattern over recent decades; overall, no specific trend is discernible. However, when the non-breeding birds are broken down by feeding behaviour, patterns do emerge. Four groups are differentiated: herbivores, benthos-eaters, omnivores and fish-eaters. The functional groups display different patterns in their development over recent decades (Figure 6-14). The number of herbivores and benthivores is falling, whereas the number of omnivores and piscivores is rising. The benthivores group has experienced some recovery since 2015.

The T2021 report concludes that different causes underlie the developments of the different functional groups. The overall picture is that many species within different functional groups appear to be following the shifts in densities of their prey species groups/vegetation zones. This results in significant positive and negative correlations between the densities of various bird species and the associated prey species groups/vegetation zones in each zone of the Western Scheldt. Apart from food availability, rest is also an important factor for non-breeding birds. Many species make use of high water refuges when they are unable to feed at high tide. Rest is not always assured there. External issues also play an important role, such as the changing of migration behaviour as a result of climate change. The latter is expected to be a factor in explaining the differences within the functional groups – for example, in the piscivores group, which displays a (slight) net positive trend, as may be seen in Figure 6-14, whereas the great crested grebe and red-breasted merganser do display a negative trend. This is probably attributable to the more northerly wintering of the other species of piscivores.

The final assessment on the situation of birds is therefore that it is variable; there is no clear trend for the entire biotic community.

Table 6-9 Overview of the seasonal averages for non-breeding bird species with conservation objectives in the Western Scheldt per period of six counting seasons between 1985 and 2021. A positive rating is given if the seasonal average for a species is above the conservation target in three of the six seasons. Green = positive assessment, yellow = probably positive but data are lacking, white = negative assessment. Numbers from Sovon (Dutch Centre for Field Ornithology)

Soort	ihd	1985-1991	1991-1997	1997-2003	2003-2009	2009-2015	2015-2021
Bergeend	4500	2.380	2.680	4.102	5.328	7.297	8.575
Bontbekplevier	430	699	438	494	440	380	337
Bonte strandloper	15100	11.578	11.518	13.638	13.872	11.216	11.494
Drieteenstrandloper	1000	487	391	835	1.228	1.117	1.133
Fuut	100	128	185	114	60	44	54
Goudplevier	1600	1.395	943	1.381	1.240	343	159
Grauwe gans	16600	4.327	9.139	17.083	13.011	8.282	6.197
Groenpootruiter	90	39	56	89	72	57	56
Kanoet	600	929	765	660	1.334	1.210	972
Kievit	4100	1.825	1.907	3.441	4.512	2.398	1.512
Kleine zilverreiger	40	0	4	24	74	57	65
Kluut	540	373	456	486	614	449	499
Kolgans	380	1.242	638	542	464	652	211
Krakeend	40	6	13	34	35	58	90
Lepelaar	30	5	10	35	41	134	189
Middelste zaagbek	30	61	66	39	12	10	10
Pijlstaart	1400	608	759	1.599	760	897	892
Rosse grutto	1200	1.255	1.135	1.192	977	826	623
Scholekster	7500	8.054	11.301	9.042	8.395	6.834	7.704
Slechtvalk	8	1	7	8	13	14	14
Slobeend	70	40	31	57	67	81	145
Smient	16600	7.504	12.316	17.117	11.240	7.304	6.146
Steenloper	230	362	275	305	201	156	206
Strandplevier	80	158	83	60	20	10	7
Tureluur	1100	933	842	1.049	918	723	741
Wilde eend	11700	7.304	7.523	10.650	9.011	7.257	5.592
Wintertaling	1100	558	575	939	655	907	1.175
Wulp	2500	2.547	2.335	2.443	3.101	3.466	3.546
Zeearend	2	0	1	1	0	1	2
Zilverplevier	1500	1.805	2.240	1.496	2.090	1.550	1.500
Zwarte ruiter	270	212	263	272	183	87	59
Soorten: n > ihd	10	8-16	8	15	13	12	14

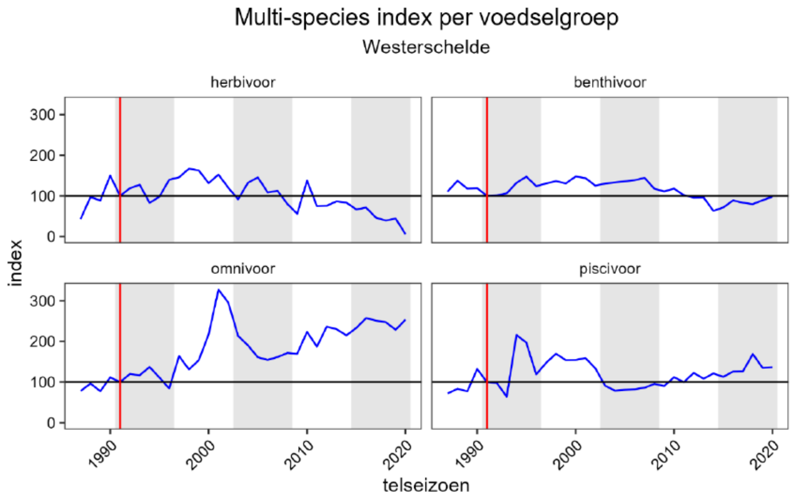


Figure 6-14 The Multi-species index (MSI) calculated per functional food group on the basis of the index value for non-breeding bird species with a conservation objective for the Western Scheldt. The value for 1991 has been taken as 100 (red line)

6.4.9 Marine mammals

As apex predators, marine mammals represent important indicators of the functioning of the underlying aquatic ecosystem. Their numbers and reproduction provide insight into the health of the food chain. These marine mammals feed primarily on fish. In the Western Scheldt, the numbers of common seal and grey seal are closely monitored; less data is available for harbour porpoises or other species. The common seal has used this area as a breeding ground for many years, whereas the grey seal primarily breeds in the area offshore of the Delta and other more distant areas. For this reason, we discuss the common and grey seal and also zoom in on reproduction for the common seal.

The trend in the populations of common and grey seals is positive in both cases. The number of common seals in the Western Scheldt has grown very substantially since 2000 (Figure 6-15 on the left). This represents a more marked growth than that seen in the Wadden Sea. The grey seal also displays an annual average growth percentage in the Western Scheldt of nearly 10% (Figure 6-15 on the right). The proportion of common seal pups has been between 13 and 25% in recent years (Figure 6-16). This is positive. In order to maintain the population in the Western Scheldt in the long term, the annual proportion of common seal pups needs to be at least 9% (red line in Figure 6-16). The reproduction percentage of common seals in the Western Scheldt is much lower than the percentages in the Wadden Sea.

The relatively lower reproduction percentage may be related to the in-migration of immature animals to the Western Scheldt. However, Dedert et al. (2015) present evidence to suggest that it may be attributable to the levels of pollutants in the Western Scheldt; in particular, the concentration of PFAS is high in common seals in the Western Scheldt. PFAS bind to blood proteins and can be passed on to the unborn young via the placenta. Bottom dwelling fish such as sole and flounder – important food for the common seal – contain high levels of PFAS. However, estimates of their stocks reveal that there are insufficient flatfish present to feed all the seals, which means that the diet of the common seal in the Western Scheldt must consist to a significant extent of pelagic fish. Pelagic fish contain lower levels of contaminants. Nevertheless, it cannot be ruled out that the seals are being negatively impacted by contaminants.

Aside from pollution, other human pressure factors consist primarily in the disturbance of resting places. Added to that is the fact that pressure from fisheries can impact the availability of food.

The final assessment on the situation of marine mammals is that it is variable, with a positive development in the overall biotic community.

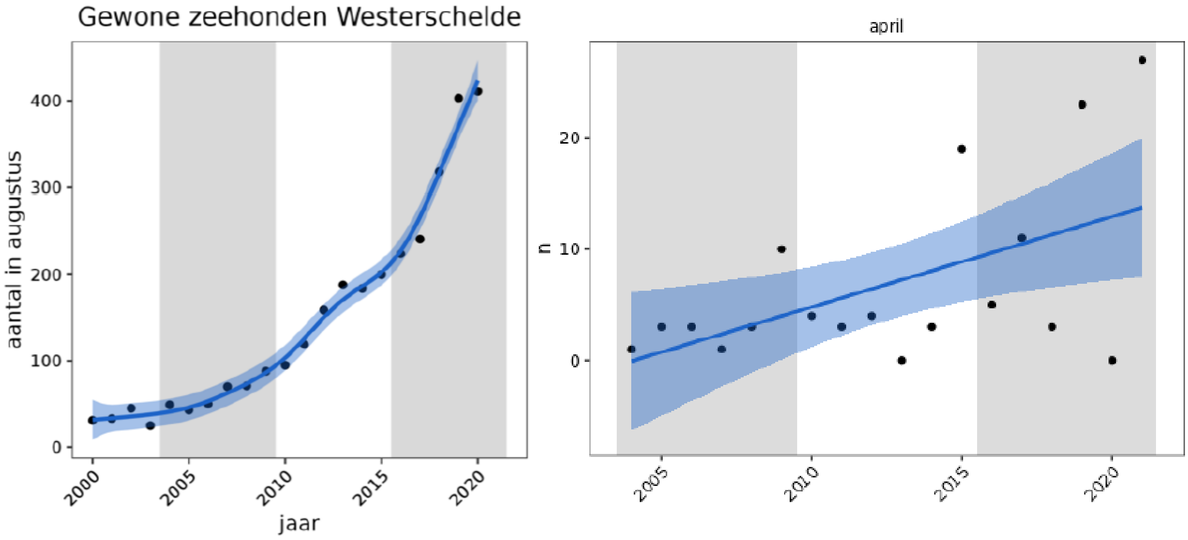


Figure 6-15 Left: The development of the common seal in the Western Scheldt during low tide counts in the moulting period (August). Right: The development of the grey seal in the Western Scheldt during low tide counts in the moulting period (April)

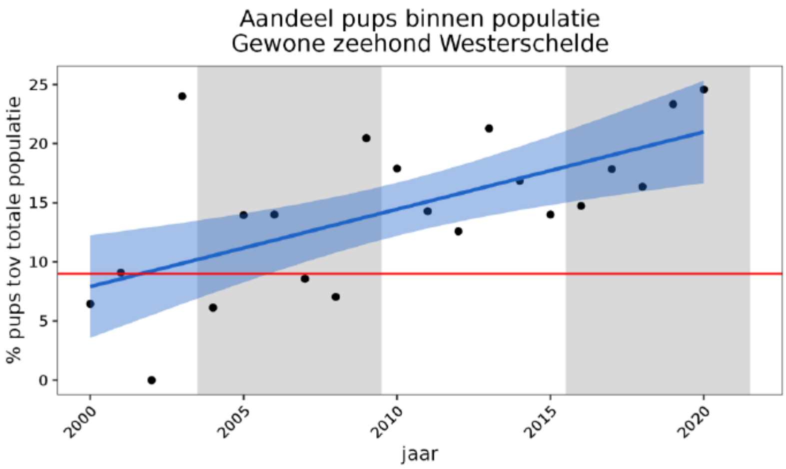


Figure 6-16 Maximum numbers of common seal pups counted in the Western Scheldt in all months of the relevant year as a percentage of the total number of common seals during the moulting period in August

6.5 Extrapolation of the ecological situation

Ecosystems are complex. Changes are constantly taking place, due to factors including abiotic variations and human influence. Those changes in turn produce new changes in the ecosystem, and so on. The dynamic and the many interactions which underlie those changes cannot be fully understood. Due to this complexity, it is virtually impossible to make a realistic prediction of what the condition of an ecosystem will be in the future. What is clear is that various autonomous developments will bring about changes to the future ecological situation around the Borssele nuclear power plant, both negative and positive. The most important autonomous developments in our opinion are shown in Table 6-10. To aid in comprehensibility, the autonomous developments are grouped into overarching themes.

In view of the above, it is not possible to predict clear positive or negative trends for biotic communities in the future with any degree of certainty. The basic assumption made is that both negative and positive factors will play a role, and that the situation of the biotic communities (summarised in Table 6-5) will continue in the same manner as before. For most biotic communities, the situation will therefore remain variable. Only for marine mammals will the (extrapolated) situation remain predominantly positive, although the accumulation of contaminants does continue to represent a concern.

In conclusion, the assumption is that the existing situation, as described in Table 6-5, will continue in the future (including after 2033). Due to the complexity of ecosystems, more concrete predictions cannot be made.

Table 6-10 The most important autonomous developments in the opinion of the authors and their influence on the ecological situation. The autonomous developments have been grouped into overarching themes

Topic	Autonomous development	Presumed influence on the ecological situation
Climate change	Higher water temperature and lower oxygen saturation	Relatively rapid abiotic changes and the increased incidence of extremes may have an increasingly negative impact on the populations of many species in and around the Western Scheldt. The vulnerable and characteristic species that generally enjoy protection are particularly vulnerable to such rapid changes in their living conditions. These species in particular may therefore decline in population size and resilience. Tolerant species may benefit from this, and may come to dominate the ecosystem more and more. These may be generalists which are currently already present in relatively large numbers, but they may also be ‘new’ species migrating from the south to the north and/or exotic species.
	Longer periods of drought with low river discharge, higher transparency and silting up of the estuary	
	Longer periods of rain with high river discharge, reduced transparency and increased freshwater content of the estuary	
Population growth and economy	An increase in population will mean more recreation and more disturbance. This is also related to longer periods of hot weather and drought.	

Topic	Autonomous development	Presumed influence on the ecological situation
	Increased shipping will cause more disturbance and turbidity/sedimentation and affect hydromorphology (wave action on dynamic riverbanks, possible need for dredging, deeper navigation channels).	It is probable that the potentially less resilient characteristic and vulnerable (protected) species, populations and biotic communities are more vulnerable to the pressure factors of the Borssele nuclear power plant.
	More disturbance as a result of projects in the region, including expected developments around Borssele Energy Hub. Depending on the activity, possibly also increased nitrogen deposition, pollution, harm/damage and turbidity.	
• **Nature restoration and increased sustainability**	Future nature restoration measures are in the offing, in part due to statutory obligations (EU). These will involve creating new biotopes or restoring biotopes.An example is the Waterdunen area near Breskens, where extensive breeding areas have been created for coastal breeding birds in particular.	Nature restoration projects can provide a positive impulse for (protected) species, populations and biotic communities and their resilience. Robust and resilient ecological values are more able to withstand environmental impacts, in this case from the Borssele nuclear power plant.
	Due to gradual improvements in sustainability, for example due to policy and statutory obligations, the nitrogen load on nature is gradually decreasing. See also AERIUS Monitor (monitor.aerius.nl).	With reduced autonomous nitrogen deposition, habitats become less and less overloaded, or even not overloaded at all. The gradual reduction of this pressure factor can lead to more robust and resilient ecological values, which are more able to withstand environmental impacts, in this case from the Borssele nuclear power plant.

6.6 Environmental impacts

Table 6-11 below provides an overview of all the impact chains. The impact chains and criteria which are assessed as potentially causing environmental impacts will be considered as issues requiring attention in EIA Phase 2.

Determination of environmental impacts (method)
As explained in Section 5.1 (methodology), the identification of the potential impacts (described in Sections 6.1 to 6.5) is followed, where possible, by their quantification based on statutory or licensed frameworks. As the reader will be aware, the Borssele nuclear power plant does not have a permit under the Nature Conservation Act (or other nature permits, e.g. under the WFD) and there are no licensed ecological frameworks. However, we do identify the relevant statutory frameworks in this chapter, based on which we describe the current ecological situation, along with the possible impact of the Borssele nuclear power plant.

For each of the criteria and biotic communities described, we conclude that negative impacts cannot be ruled out. Once the future situation is clearer, as it will be when the EIA Phase 2 is performed, it will be possible to quantify the impacts in more detail. That knowledge is required in order to be able to determine which consequences for nature are acceptable, the more so because this is related to potential specific mitigating measures. Based on the current research, we have identified the elements which contribute to the overall environmental impact of the Borssele nuclear power plant. Fewer environmental impacts are anticipated for groups of species which have limited intersections with the activities of the Borssele nuclear power plant, such as bats, amphibians and flora on land. It has therefore been decided not to highlight the current situation of those species groups. Section 6.7 lists the most relevant elements identified for EIA Phase 2.

Environmental impacts in current situation = Environmental impacts in future situation
The basic assumption is that environmental impacts in the event of an operating life extension beyond 2033 will be comparable to those shown in Table 6-11, the reason being that extrapolating the ecological situation does not yield any specific (positive or negative) patterns. It is therefore assumed that the situation will remain similar (as explained in Section 6.5). In its response (Section 4.4), the EIA Committee indicates that relatively detailed studies are relevant at this stage to obtain clarity on how much scope (if any) nature protection offers for a potential operating life extension for the Borssele nuclear power plant. The research carried out to date does not provide an answer to this question and indicates that it depends on a complex interrelation of elements and that a number of biotic communities around the Borssele nuclear power plant are under pressure (see Section 6.5). The environmental impacts shown in Table 6-11 are therefore representative of both the current and future ecological situations.

Transboundary environmental impacts
Ecosystems and the interactions within them do not end at national borders. This means that the environmental impacts of the Borssele nuclear power plant on biotic factors may also be transnational. The ecological framework elucidated above also takes adequate account of such potential transboundary environmental impacts for the level of detail of EIA Phase 1. This is because the ecological framework includes the most characteristic and vulnerable biotic communities, biotopes and species for the area around the Borssele nuclear power plant. Viewing the criteria within this framework yields an appropriate insight into the pressure on the surrounding ecosystem. This is regardless of whether they extend beyond a national border.

Because transboundary environmental impacts cannot be ruled out, EIA Phase 2 will also need to take account of statutory frameworks relating to ecology outside the Netherlands, on the basis of the Espoo Convention. This has been listed as an agenda item in the final section of this chapter, ‘Outlook for EIA Phase 2’.

Table 6-11 Overview of environmental impacts. ***Direct environmental impacts:*** *A direct impact on a biotic community. For example, the potential killing, harming or disturbing of species (e.g. direct impact from drawing in fish).* ***Indirect environmental impacts:*** *An indirect impact on a biotic community. For example, a knock-on effect via the food chain (e.g. indirect impact on fish-eating predators from drawing in fish)*

Criterion	Potentially affected biotic community	Direct/indirect environmental impacts	Current situation and extrapolation to future situation (>2033)	Relevant elements of ecological framework
Extraction and discharge of cooling water	Habitat types (quality)	Direct	Variable	N2000
	Phytoplankton	Direct	Variable	WFD, (N2000 indirect)
	Zooplankton (including macrofauna and fish larvae)	Direct	Unclear	N2000, FF, WFD (only indirect)
	Migratory fish and other fish	Direct and indirect	Variable	N2000, FF, WFD
	Breeding and non-breeding birds	Indirect	Variable	N2000, FF, NNZ
	Marine mammals	Indirect	Predominantly good	N2000
Disturbance and damage/harm	Breeding and non-breeding birds	Direct	Variable	N2000, FF, NNZ
	Marine mammals	Direct	Variable	N2000, FF
	Other species groups (vegetation on land, bats, ground-based mammals, amphibians)	Direct	Not considered	FF, NNZ
Turbidity and sedimentation	Habitat types (quality)	Direct	Variable	N2000
	Phytoplankton	Direct	Variable	WFD, (N2000 indirect)
	Water and coastal flora	Direct	Variable	WFD, N2000
	Macrofauna	Direct	Variable	WFD
	Migratory fish and other fish	Direct and indirect	Variable	WFD, N2000, FF
	Breeding and non-breeding birds (birds that hunt for fish and macrofauna by sight)	Direct and indirect	Variable	N2000, FF, NNZ
	Marine mammals	Indirect	Predominantly good	N2000, FF
Pollution	Habitat types (quality)	Direct	Variable	N2000
	Phytoplankton	Direct	Variable	WFD, (N2000 indirect)
	Water and coastal flora	Direct	Variable	WFD, N2000
	Zooplankton (including macrofauna and fish larvae)	Direct	Variable	N2000, FF, WFD (only indirect)
	Macrofauna	Direct	Variable	WFD
	Migratory fish and other fish	Direct and indirect	Variable	WFD, N2000, FF
	Breeding and non-breeding birds (in connection with aquatic environment)	Direct and indirect	Variable	N2000, FF, NNZ
	Marine mammals	Direct and indirect	Predominantly good	N2000, FF
Nitrogen deposition	Nitrogen-sensitive habitat types (quality)	Direct	Variable	N2000
	Nitrogen-sensitive management types	Direct	Variable	NNZ

6.7 Outlook for EIA Phase 2

During EIA Phase 2, it will be clear whether any physical adjustments to the nuclear power plant are necessary. This section discusses elements of the present EIA Phase 1 which are relevant for the next phase.

What needs to be addressed in a more detailed assessment in EIA Phase 2 may be heavily influenced by any ‘existing public law rights’ of the Borssele nuclear power plant. This is because if there are existing public law rights for particular aspects of the activity, no permit is required for those aspects. We therefore recommend establishing legal clarity with regard to what does and does not fall under any existing public law rights of the Borssele nuclear power plant before commencing EIA Phase 2. If there are no existing public law rights, part of EIA Phase 2 will be to establish mechanisms to review the relevant statutory frameworks. This will in any event include an Appropriate Assessment within the framework of Natura 2000, an assessment of (temporary) deterioration of the water quality within the framework of the WFD, an assessment within the framework of protected Flora and Fauna and an assessment within the framework of the Zeeland Nature Network. Potential transboundary effects and additional statutory obligations also need to be considered. This may include mitigating measures that can be reasonably taken to compensate for or ameliorate significant negative impacts on protected ecological values.

This EIA Phase 1 chapter on ecology reveals that a number of activities of the Borssele nuclear power plant have environmental impacts on the ecosystem, in particular the extraction and discharge of cooling water, pollution and nitrogen deposition. This underlines the need for a more detailed ecological assessment in EIA Phase 2. It should be pointed out that the impact chains whose environmental impacts are limited cannot simply be omitted in a more detailed assessment; they must also be considered in more detail.

For EIA Phase 2, it is also important to gain insight into the knowledge gap around the disturbance and damage/harm caused by the Borssele nuclear power plant. Other knowledge gaps that have the potential to complicate the assessments in EIA Phase 2 to some extent are the complex interactions in the ecosystem and the unclear situation of zooplankton. It is not expected that the latter two knowledge gaps will be resolved within the foreseeable future.

The above conclusion is summarised below as a list of agenda items for EIA Phase 2.

- With regard to the identified environmental impacts:
  - **Nitrogen deposition** is an environmental impact that requires further investigation in EIA Phase 2 (ecology). Any knock-on effects on fauna are also relevant.
  - **Extraction and discharge of cooling water** is an environmental impact that requires further investigation in EIA Phase 2 (ecology).
  - **Pollution** in general is an issue requiring attention for EIA Phase 2 (ecology) – in particular the impact on marine mammals, which are very susceptible to the accumulation of pollutants.
- With regard to the recommended more detailed assessments and the possibility of permits being granted:
  - Depending on the outcomes with regard to existing public law rights, a **more detailed assessment** will be necessary within the framework of **Natura 2000**, **WFD**, **Flora and Fauna**, and **NNZ**.
  - If necessary, **mitigation measures** can be explored and put forward in EIA Phase 2. These are measures that could compensate for or ameliorate any significant negative impacts.
  - It cannot be ruled out that environmental impacts may **extend beyond national borders**. In EIA Phase 2, this will need to be investigated in more detail, after which account may need to be taken with statutory frameworks outside the Netherlands.
- With regard to knowledge gaps:
  - The **disturbance and damage/harm** caused by the Borssele nuclear power plant are relatively unclear. In order to be able to properly assess the impacts in EIA Phase 2, it is important that more details about this become available.
  - In a general sense, there are **knowledge gaps** associated with the complex interactions that influence the ecosystem. The situation of the zooplankton community is also relatively unknown. This has the potential to impede the assessment of the impacts of the Borssele nuclear power plant in EIA Phase 2 to some extent. It is not expected that these knowledge gaps will be completely resolved in the near future.

7 Radiation protection during regular operations

7.1 Introduction

The potential radiological effects on various groups were considered when assessing radiation protection during the regular operations of the EPZ nuclear power plant. The mitigation and regulation of these effects are subject to legal criteria set out in legislation and regulations. For details, please see Section 7.2. These criteria are explained in greater detail, with the emphasis more on quantitative aspects, in Section 7.3. Section 7.4 sets out the prevailing situation at the EPZ nuclear power plant and describes how the legal requirements are met. Waste management is also discussed in the process. Finally, Section 7.5 looks ahead to future developments and their impact on aspects of radiation protection.

For a better understanding of these matters, this introduction presents some basic knowledge about radiation protection, with the focus on EPZ's operations where necessary.

7.1.1 Ionising radiation and radiation sources

'Ionising radiation' is the name for any high-energy radiation capable of ionising substances. This releases an electron from an atom, which may damage the material in which the atom is contained. If this is living tissue, it can be harmful to the health of humans and animals. That is why the exposure to ionising radiation must be kept to a level that is as low as reasonably possible.

Ionising radiation can be emitted from natural sources as well as artificial ones. Examples of natural sources include:
- Radiation from space, so-called 'cosmic radiation'. This kind of radiation is more intense at higher altitudes because it is not protected as much by the atmosphere. Exposure to cosmic radiation in an aeroplane or on a mountain is therefore higher than it is at sea level.
- Radiation from the ground. This kind of radiation is emitted from a range of minerals in the soil, which by their nature emit ionising radiation. The radioactive noble gas, radon, is also released from the soil. The amount of radiation emitted from the soil is heavily dependent on the substrate at the location. Ground radiation is low in the Netherlands.

Substances that can emit ionising radiation are known as 'radioactive substances'.

Ionising radiation may also have an artificial source, such as:
- Radiation from X-ray machines when taking X-rays.
- Radioactive substances used in the medical sector for diagnosing or treating tumours.
- Radioactive sources used for measurements in industry and research.
- Radioactive substances created in nuclear power plants when producing electrical energy.
- Neutrons released during nuclear fission in a nuclear power plant.

7.1.2 Sources of ionising radiation in the nuclear power plant

The main source of ionising radiation in a nuclear power plant is the reactor core. It mainly emits fast (high-energy) neutrons and gamma rays. Neutrons are released during the fission of uranium or plutonium cores. Gamma rays are produced by so-called 'fission products' formed by the splitting of the atoms and are also produced by neutron capture in the reactor core, water and shielding materials.

Other significant sources of ionising radiation in the nuclear power plant are:
- The concrete around the reactor vessel that becomes radioactive (activated) to some degree due to being irradiated with neutrons. This has to be taken into account when carrying out maintenance work on a reactor that has been shutdown.
- The main coolant in the primary cooling circuit produces N-16, the nitrogen radioisotope that is the main contributor to the radiation emitted inside the reactor building during operations.
- The air in the reactor building and reactor auxiliary building may also be somewhat radioactive.
- The spent fuel elements that are stored in the fuel storage basin, especially the ones put there recently, are a source of radiation on-site.

- Radioactive materials stored in the waste storage building and other storage areas within the controlled area. The waste storage building contains containers of radioactive waste that are periodically disposed of at COVRA.
- Occasionally there are fuel containers on site, sometimes with 'fresh' or new fuel, sometimes with spent (and therefore more radioactive) fuel. The new nuclear fuel is moved directly to the reactor building. The containers of spent fuel are prepared for transport for processing abroad.
- Transport of nuclear and radioactive materials.

Radioactive sources used for measurements (as part of measuring instruments) or calibrating measuring equipment are a separate category of radioactive sources.

7.1.3 Various kinds of ionising radiation and their properties

Radioactive materials can emit various kinds of ionising radiation. The ones most commonly known are alpha, beta and gamma rays. This radiation can be blocked through shielding. The shielding required varies per type of radiation.
- Alpha rays have a very low capacity to penetrate and can be completely blocked, even with a piece of paper. Internal contamination is the main factor affecting health. Precisely because of their low penetrating power, alpha rays release all their energy into a small amount of tissue, and can cause local damage.
- Beta rays have a slightly higher penetrating power, but can be stopped, for instance, by a layer of water measuring one cm.
- Gamma rays have greater penetrating power. Concrete, water, iron or lead are usually used as shielding material against gamma rays.
- Neutron radiation is also ionising. As described above, it is created in the reactor core of the nuclear power plant during the fission of atomic nuclei. Because it is shielded by water in the reactor core and the various kinds of shielding around it (stainless steel, steel and concrete), this radiation has no impact on the surroundings of the nuclear power plant. Neutron rays around the reactor core can become activated, causing these materials to become radioactive.

7.1.4 Potential exposure routes

Experts in the field of radiation protection refer to the ways in which humans and other organisms can be exposed to ionising radiation as 'exposure routes'.

The effects of radiation on the environment can be caused by:
- Direct radiation from the plant or from radioactive materials present in the plant or on the Borssele nuclear power plant site. Direct alpha and beta radiation from radioactive materials present in the plant or on the Borssele nuclear power plant site is completely blocked by the type of storage, which provides adequate shielding. Because of this, gamma rays are the only type relevant for direct radiation under normal operating conditions.
- This occurs due to discharge into the air of radioactive gases and aerosols (small suspended particles), or radioactive materials discharged in wastewater. These materials will emit radiation. When radioactive substances are dispersed, they can enter the body through inhalation or through eating and drinking. Alpha and beta radiation are also relevant to this route because the body provides little or no protection.

7.1.5 Levels of radioactivity and exposure to radiation

The radioactivity of a substance is also known as 'activity' and is expressed in the becquerel (Bq). This describes the number of atomic nuclei that decay radioactively per second. For this, 1 Bq represents a rate of radioactive decay equal to 1 disintegration per second.

The radiation dose received at a given site and for a given period of time spent there is expressed in sievert (Sv). This is the unit used to express the biological effect of ionising radiation on body tissue. Using sievert as a measure is for relatively low doses; the main risk to human health is developing cancer. The dose is usually expressed in millisievert (mSv), a thousandth part of a sievert. At a nuclear power plant, people are exposed to radiation that falls within the sievert scale. The unit 'gray' (Gy) is used for higher doses. Please refer to Section 7.1.6 for more information about the impact that ionising radiation has on health.

Two types of dose are often used in legal criteria for limiting the dose load. The first is the effective dose, which is the yardstick for the dose that the individual (the entire body) receives. The definition of the effective dose, E, is given in the Dutch Decree on Basic Safety Standards Radiation Protection [*Besluit basisveiligheidsnormen Stralingsbescherming*] (Nederlandse overheid, 23 oktober 2017). It is the sum of the weighted equivalent doses to all the tissues and organs listed in Table 2 of the decree, and attributable to internal and external irradiation: $E = \sum_T w_T H_T$ where H_T is the equivalent dose in tissue or organ T and w_T is the tissue weighting factor as given in Table 2 of the decree. The unit for effective dose is the sievert (Sv).

The second is the equivalent dose, which is the yardstick for the dose that the individual receives in specific tissue or a specific organ. The definition of the equivalent dose is described in the decree mentioned above (Nederlandse overheid, 23 oktober 2017). The equivalent dose, H_T, to a tissue or organ T is the sum of the products of the mean absorbed dose, $D_{T,R}$, to a tissue or organ T imparted by radiation R, and the radiation weighting factor w_R: $H_T = \sum_R w_r D_{T,R}$. The unit for effective dose is the sievert (Sv).

7.1.6 Impact of ionising radiation on health

Exposure to ionising radiation can affect the health. This is because ionising radiation damages the DNA material of body cells. Most damage to DNA is restored by the body's repair mechanism, but in some cases it fails. DNA damage that is not repaired at all or not properly can be harmful to health, such as the onset of cancer decades after exposure. The radiation we are all exposed to in our normal lives contributes to the risk of getting cancer, but the number cancer cases caused by radiation is small compared to the number of cases from other causes.

Exposure to ionising radiation does not mean that you will definitely get cancer. Indeed, it is much more likely that you will not get cancer than that you will. However, the more radiation you get, the more likely you are to get cancer as a result. Because chance is such an important factor in this process, we refer to this a 'stochastic health effects'.

For low doses of radiation, the amount of radiation that you receive is expressed in millisievert (mSv). Research has taught us that the relationship between the amount of radiation you receive and the heightened likelihood of developing cancer, namely the increase in likelihood for a radiation dose of 200 millisieverts, is about 1 per cent.

For radiation protection purposes, it is assumed that there is a linear relationship between the radiation dose and the risk of developing cancer. This means that if ten thousand people all get a 2 millisieverts radiation dose, this statistically causes cancer in one person over the course of years. But, at the same time, around three thousand people from this same cohort develop cancer from other causes. Research cannot definitively determine whether one person in this group actually gets cancer from radiation at this dose: after all, one additional case in about 3, 000 is not demonstrable in practice. For comparison purposes: on average, members of the population in the Netherlands get a radiation dose of almost three millisieverts per year.

If the DNA damage in a cell after irradiation is so great that it cannot be repaired, the cell dies. As long as it involves only one cell, cell death is not serious, after all, we have plenty of body cells. In other words, if the number of cells killed through radiation is limited, this is not harmful to health. Extremely high levels of exposure, however, are harmful to health. This is then known as the 'deterministic effect'.

Situations in which people are unintentionally exposed to extremely high radiation doses are very rare. Around 200 people have died worldwide due to radiation sickness in the past 40 years. These cases concern accidents in the industry or mistakes made during medical treatment. The most well-known incident in this respect is the Chernobyl nuclear disaster, in which several emergency workers died of radiation syndrome after being deployed too close to the exploded reactor. This was not the case in Fukushima. As a general rule, the amount of radioactivity that may enter the environment after a nuclear power plant accident is too low to cause radiation sickness in members of the population (RIVM, 2024).

7.1.7 Description of the state of radiation protection

When describing the state of radiation protection, the potential exposure to ionising radiation of staff, those living in the vicinity, employees working at neighbouring businesses and the environment – and how this exposure meets the criteria for it – are taken into consideration.

Regarding radiation protection at the Borssele nuclear power plant, the effects of the possible exposure pathways outside the site of the plant were considered:

- Direct radiation.
- Emissions of radioactive materials.

The area studied for each of the exposure pathways is determined according to the sites where the radiation dose is greatest. For direct radiation into the environment, this will usually be directly at the plant's boundary. For radioactive emissions into the environment, this depends on the dispersion, which in turn depends on other factors, like weather conditions for instance. The models used to calculate the radiation dose due to emissions from normal operations usually assume an area of 25 km around the plant. Emissions into the soil are not assessed; these emissions are prohibited by law and are prevented by technical and organisational measures.

7.2 Relevant policy frameworks

This section discusses the relevant legislation and regulations and the policy framework for radiation protection. A selection of the key documents are discussed. This concerns the prevailing legislation and regulations that determine the relevant frameworks and/or conditions.

The table below gives the legal and policy frameworks at a national and international level.

Table 7-1 Legal and policy frameworks for radiological effects

Policy, legislation and regulations	Contents and relevance
The Dutch Nuclear Energy Act [*Kernenergiewet*] (Nederlandse Overheid, 21 febr. 1963)	All operations involving ionising radiation in the Netherlands fall under the regime of the Nuclear Energy Act, which provides the basis for protecting the population, the environment, workers and patients from the adverse effects of ionising radiation. The Act does this by requiring that a permit be obtained for most actions involving sources of ionising radiation. The Act is set out in greater detail in the Nuclear Facilities, Fissionable Materials and Ores Decree, the Decree on Basic Safety Standards Radiation Protection, and the associated regulations. The Borssele nuclear power plant currently holds a permit under the Act for operating a facility in which nuclear energy can be released (Section 15(b)); holding nuclear fuel (Section 15(a)), holding, applying and disposing of radioactive substances (Section 29(1)) and performing operations with devices (Section 34).
Nuclear Facilities, Fissionable Materials and Ores Decree ('the Decree') (Nederlandse Overheid, 4 sept 1969)	This Decree sets out general rules regarding the provision of information when applying for a permit under the Act and the criteria under which an application can be refused, for instance, if the risks do not meet the legal limits.
Decree on Basic Safety Standards Radiation Protection (Nederlandse overheid, 23 oktober 2017) and its associated regulations, including the Regulation on Basic Safety Standards for Radiation Protection laid down by the Authority for Nuclear Safety and Radiation Protection (ANVS) (Nederlandse Overheid, 9 januari 2018)	This Decree on Basic Safety Standards Radiation Protection sets rules for the protection of the population, the environment, the workforce and patients against the harmful consequences of ionising radiation. It also includes grounds for rejecting a permit. The decree is based on Council Directive 2013/59/Euratom, which implements the recommendations of the International Commission on Radiological Protection (ICRP).

Policy, legislation and regulations	Contents and relevance
Regulation on Safety of Nuclear Facilities (Nederlandse Overheid, 6 juni 2017)	This is a ministerial regulation providing for nuclear safety at nuclear plants and is subordinate to the Nuclear Energy Act. The regulation implements Directive 2014/87/Euratom of 8 July 2014.
Convention on Environmental Impact Assessment in a Transboundary Context, as provided for in the Dutch Environmental Management Act [*Wet Milieubeheer*] (Espoo, 25 februari 1991)	This is a UN treaty on environmental impact assessments in a transboundary context.

For assessing the radiological aspects of the nuclear power plant's normal operations, the Decree on Basic Safety Standards Radiation Protection and associated regulations, and the ANVS regulation are the most important; together they form the basis for radiation protection. The decree protects various groups affected by ionising radiation: workers, patients, the public and the environment. Three basic principles are used for this, namely the justification principle, the optimisation principle and dose limits:

- The justification principle implies that the advantages and disadvantages of an action involving ionising radiation must be weighed against each other.
- The optimisation principle implies that all exposure resulting from actions must be limited as much as reasonably achievable, with social and economic factors as well as the current state of technology being taken into account. This is also known as the 'ALARA principle': 'as low as reasonably achievable'.
- Dose limits set the limits that must not be exceeded under any circumstances.

When an action is justified and the dose is optimised as a result, the Decree on Basic Safety Standards Radiation Protection sets the limits for three different cohorts: workers exposed at work, workers not exposed at work and visitors and the population outside the site of the nuclear power plant. Please refer to the section entitled 'Criteria' for this.

7.3 Criteria

In this section, the criteria are those laid down in prevailing legislation and regulations.

The area studied in terms of radiation protection is defined by the sites where the radiation dose as a result of normal operations is greatest. As far as direct radiation for staff is concerned, this will usually be in the plant and, for the public, it will be directly at the plant's boundary. As far as radioactive discharge into the air and water is concerned, this depends heavily on the resulting dispersal, for instance due to the weather. The models used to calculate the radiation dose due to discharges is calculated according to the provisions of the ANVS's Regulation on Basic Safety Standards for Radiation Protection (Nederlandse Overheid, 9 januari 2018) assuming an area of 25 km around a reactor (DOVIS-A (RIVM, 2002)).

7.3.1 Dose limits

Dose limits have been set for exposure. The table below gives the different cohorts with the dose limits that apply to them. The table distinguishes between persons, labelled 'Category A', who work in so-called 'controlled areas' of a nuclear plant, and persons, labelled 'Category B', who work in 'supervised areas'. The risk of greater exposure is more likely in a supervised area.

Table 7-2 Assessment framework for radiation protection according to the Decree on Basic Safety Standards Radiation Protection expressed in dose limits

Assessment criteria	Individual assessment criteria in the Decree on Basic Safety Standards Radiation Protection
Staff exposed to radiation in the course of their duties at EPZ, Category A (controlled area)	Maximum effective dose of 20 mSv per year Maximum equivalent dose of 20 mSv per year for the lenses of the eye Maximum equivalent dose of 500 mSv per year on the skin[35] Maximum equivalent dose of 500 mSv per year on the extremities[36]
Staff exposed to radiation in the course of their duties at EPZ, Category B (supervised area)	Maximum effective dose of 6 mSv per year Maximum equivalent dose of 15 mSv per year for the lenses of the eye Maximum equivalent dose of 150 mSv per year on the skin Maximum equivalent dose of 150 mSv per year on the extremities
Staff not exposed to radiation in the course of their duties at EPZ, Category B (supervised area)	Maximum effective dose of 1 mSv per year Maximum equivalent dose of 20 mSv per year for the lenses of the eye Maximum equivalent dose of 50 mSv per year for the skin Maximum equivalent dose of 50 mSv per year on the extremities
The population outside the EPZ site	Maximum effective of dose 0.1 mSv per year Maximum equivalent dose of 50 mSv per year for the skin

For staff not exposed to radiation in the course of their duties, visitors and the general public outside the plant site, these persons do not come into close contact with sources of ionising radiation from the nuclear power plant. For staff exposed during their work, proximity to these sources while working cannot be excluded a priori.

It should be noted that the effective dose for the population outside the site of the nuclear power plant must be lower or equal to 0.1 mSv per year according to the decree, and lower or equal to 0.010 mSv per year according to the plant's current permit under the Nuclear Energy Act.

Transport of radioactive materials to and from the nuclear power plant forms a potential source of exposure to ionising radiation. All transport of radioactive substances must comply with the Nuclear Facilities, Fissionable Materials and Ores Decree (Nederlandse Overheid, 4 sept 1969)) and the ADR (*Accord européen relatif au transport international de marchandises Dangereuses par Route*) (ADR, 2023) regulations. The ADR is the European agreement on the international carriage of dangerous goods by road.

7.3.2 Discharge limits

Emissions of radioactive substances into air or on surface water may contribute to the effective dose outside the site of the nuclear power plant. The criterion for discharge into the ground is that discharge into the ground is prohibited. This objective is achieved based on the plant's design and technical facilities as well as procedures at the plant.

The ANVS has set the following discharge limits for the nuclear power plant in Borssele.

Table 7-3 Annual limits for the permit under the Nuclear Energy Act for discharge into surface water

Assessment criteria	Annual limit
Beta and gamma emitters (excluding tritium)	200 GBq
Tritium	30 TBq
Alpha emitters	200 MBq

[35] Whereby the dose has to be spread homogeneously across the skin, i.e. each square centimetre of skin has to exposed to the same extent.
[36] 'Extremities' refers to the hands, forearms, feet and ankles.

Table 7-4 Annual limits for the permit under the Nuclear Energy Act for discharge into the air

Assessment criteria	Annual limit
Noble gases	500 TBq
Halogens	50 GBq, whereby not more than 5 GBq of iodine-131
Aerosols	500 MBq
Tritium	2 TBq
Carbon-14	300 GBq

7.3.3 Parameters for radioactive waste management

The waste policy in the Netherlands

Many industrial activities in the Netherlands generate radioactive waste, and nuclear power generation is one of the ways radioactive waste is produced. Radioactive waste can remain hazardous for a long time, which is why it has to be managed properly.

The waste policy in the Netherlands is based on four guiding principles, as laid down in the National programme for the management of radioactive waste and spent nuclear fuels (Ministerie van Infrastructuur en Milieu, 2016):

- Minimising the creation of radioactive waste.
- The safe management of radioactive waste.
- No undue burdens should be placed on the shoulders of future generations.
- The costs of managing radioactive waste must be borne by the plants producing the waste.

COVRA N.V. collects all radioactive waste centrally in the Netherlands, where they store it above ground for at least 100 years. The part of the waste that is still radioactive after that time will be stored deep underground, according to the current assumption; this is called final disposal. The producers of the waste pay certain waste collection fees, which COVRA N.V. uses to bear the costs of current and future waste management. Pricing also acts as an additional incentive to produce as little radioactive waste as possible. With the transfer of the waste to COVRA, the responsibility for this waste also passes to COVRA. COVRA imposes certain requirements on the waste delivered and the packaging in which the waste is transferred, so that COVRA is able to isolate, manage and control the radioactive waste.

Spent nuclear fuel can be reused; this is known as 'reprocessing'. Usable substances are extracted from the fuel during this process. Under the policy in the Netherlands, operators are free to decide whether or not to opt for reprocessing. In 2022, the government stated its preference for reprocessing.

Waste management requirements for a permit under the Nuclear Energy Act

The plant is permitted to temporarily store waste, which is later transferred to COVRA N.V., in a building designed for that purpose. The plant has to keep proper records of waste materials.

7.4 Description of the current situation

The National Institute for Public Health and the Environment (RIVM) has estimated that people living in the Netherlands receive an average total effective annual dose of 2.8 mSv. The biggest contribution to the total average annual dose in the Netherlands comes from radiation in the indoor environment (radon, thoron, gamma radiation from building materials), radiation from medical diagnostics (such as computed tomography and CT scans), natural radioactivity in the body and cosmic radiation. The combined contribution of industry, consumer products and fallout (from nuclear weapons testing) is less than 1% of the total annual effective dose per member of the population. Industries include processing industries working with bulk materials containing natural radioactive materials. The Borssele nuclear power plant also falls under 'industry', but as part of this category it contributes very little to the radiation dose (see Section 7.4.2.3). Examples of consumer products that can cause radiation doses include radioactive smoke detectors for individuals and radioactive glow plugs for camping gas burners, which have been taken off the market. These items are gradually disappearing from households in the Netherlands and, with that, their contribution to radiation doses are disappearing too.

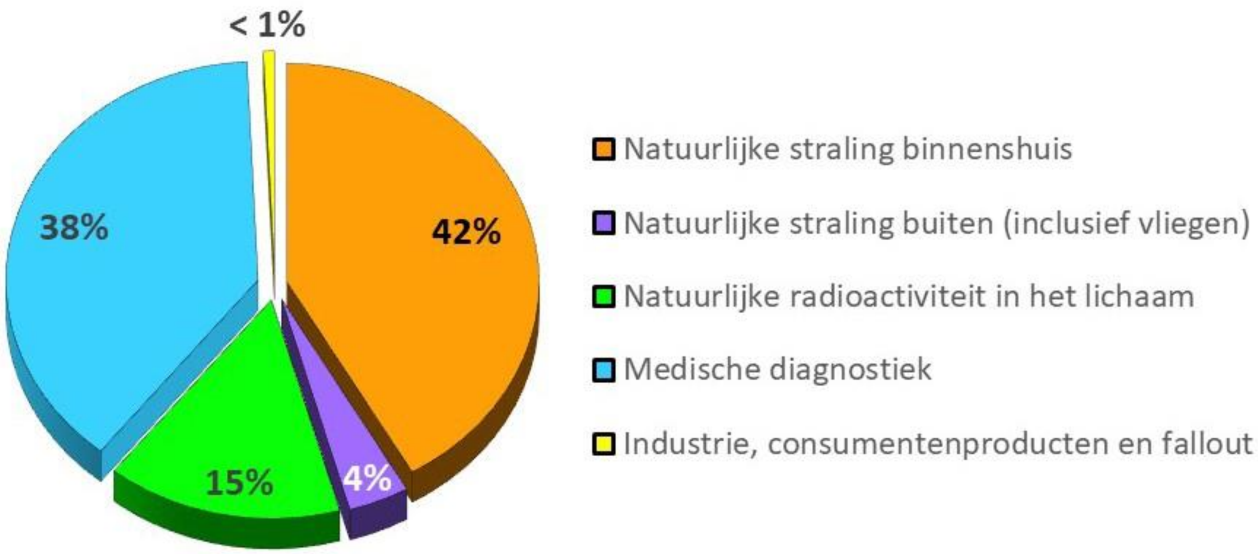


Figure 7-1 Annual average radiation dose per person in the Netherlands as calculated by RIVM and published on the RIVM site

Several subsections below discuss the current situation at the nuclear power plant in terms of radiation protection and waste management.

7.4.1 Radiation on and around the nuclear power plant

7.4.1.1 Staff exposed in the course of their work

Two categories

Every day, external staff work at the nuclear power plant. Throughout the year, work is carried out there and some of it is done in the radiological zones. Those who have to work in these areas may be exposed to doses of ionising radiation that are higher than the background radiation. These people are known as ‘occupationally exposed staff’. Because exposure to radiation can pose a health risk, legal limits and requirements have been drawn up and laid down in the aforementioned Decree on Basic Safety Standards Radiation Protection and associated regulations.

There are two categories of occupationally exposed staff: Categories A and B. The important requirements for staff who are exposed in the course of their work is that they are adequately informed about radiation protection and that they keep a track of the radiation dose incurred per individual. At the same time, all occupationally exposed employees in Category A are under the medical supervision of a qualified radiation practitioner.

Radiation protection facilities

There are many facilities available and measures are in force in the plant aimed at restricting the dose that staff receive. For instance, the shielding of the radioactive sources is sufficient. Where necessary, protective clothing is worn to prevent radioactive contamination. The ventilation system prevents the spread of radioactivity in the air, if there is any, by removing it through filtering. There are also instruments to enhance radiation protection. These instruments are used to continuously measure radiation levels in buildings and systems.

The plant is also divided into zones. Each area within the so-called controlled zone has a sign with relevant information such as:

- The dose rate, i.e. the dose that may be absorbed during a specific period of time.
- The likelihood of surface contamination and air contamination.
- Whether or not the area may be entered, whether permission must be requested or whether supervision or special facilities are required.

Occupationally exposed staff have two dosimeters: an EPD (electronic person dosimeter) and a TLD (thermoluminescent dosimeter). The EPD gives immediate readings, so the employee has relevant information while working. A dosimetry service reads the TLD data each month, and effectively gives a dose aggregated over the month.

This dosimetry service has to be accredited by the ANVS pursuant to Article 7.15 of the Decree on Basic Safety Standards Radiation Protection. Dose levels are recorded in the National Dose Registration and Information System (NDRIS). NIDRIS was established in 1998 and the use of the system is laid down in Article 7.17 of the decree.

Occupational exposure of staff complies with the set criteria

Every year, the plant manages to keep the radiological exposure of occupationally exposed employees below the applicable legal assessment criteria for this purpose, as stipulated in the permit under the decree mentioned above and the Nuclear Energy Act. The plant also meets the stricter criteria that the Borssele nuclear power plant applies internally.

7.4.1.2 Staff not exposed in the course of their work

A large proportion of the staff do not come into contact in the course of their work, and thus are not exposed to higher doses of ionising radiation than they would be due to background radiation. As laid down in the decree mentioned above, the effective dose of these members of staff may not be greater than 1 mSv per year. The effective dose for staff at the nuclear power plant who are exposed in the course of their work complies with this requirement year on year.

7.4.1.3 Population outside the site of the nuclear power plant – direct radiation

Radioactive materials in the various buildings at the plant are responsible for the maximum amount of radiation exposure outside the nuclear power plant site. Radiation from radiological emissions and direct radiation from buildings and objects on the premises during normal operations cause the radiation dose. We restrict ourselves to direct radiation in this section. See Section 7.4.2 for emission into the air and water, how this is monitored and how the consequences of doses are determined.

Monitoring the dose rate around the nuclear power plant by EPZ's radiation monitoring network and RIVM's monitoring network

EPZ measures the dose rate on an ongoing basis using GM detectors installed at eight points on the site boundary and at eight points in the vicinity of the nuclear power plant. EPZ has to ensure that the exposure of persons outside the site boundary, corrected to take into account their limited presence, does not exceed 0.010 mSv per year. This dose is known as the 'current individual dose'. In practice, this dose always remains well below the limit allowed under the permit, as evidenced by reports from EPZ to the ANVS, but also by check measurements carried out by RIVM on behalf of the ANVS. Direct radiation from the buildings is thus limited to the immediate vicinity of the nuclear power plant and is always low at the site boundary compared to the annual limit under the permit.

For independent verification, RIVM continuously measures the radiation dose rate at eight points along the site boundary using the so-called MONET monitoring network, which is managed by RIVM. The measured values derived from MONET measurements are corrected mathematically for naturally occurring radiation, i.e. the natural background level. The level measured, as with EPZ's own measurements, is then corrected by the so-called 'current exposure correction factor', i.e. the ABC factor. That factor is 0.2 in the vicinity of the nuclear power plant, which is the level that corresponds to 'industrial area'. Year on year, the RIVM has noted that their measurements and the measurements taken by the EPZ correspond well. The most recent RIVM report presents the conclusions for the 2022 measurement year (RIVM, RIVM-briefrapport 2023-0315, 2023). The highest dose at any one measurement point was 0.0009 millisievert per year. After correction using the ABC factor (0.2), this is 0.0002 millisieverts per year, which is well below the criterion of 0.010 millisieverts per year.

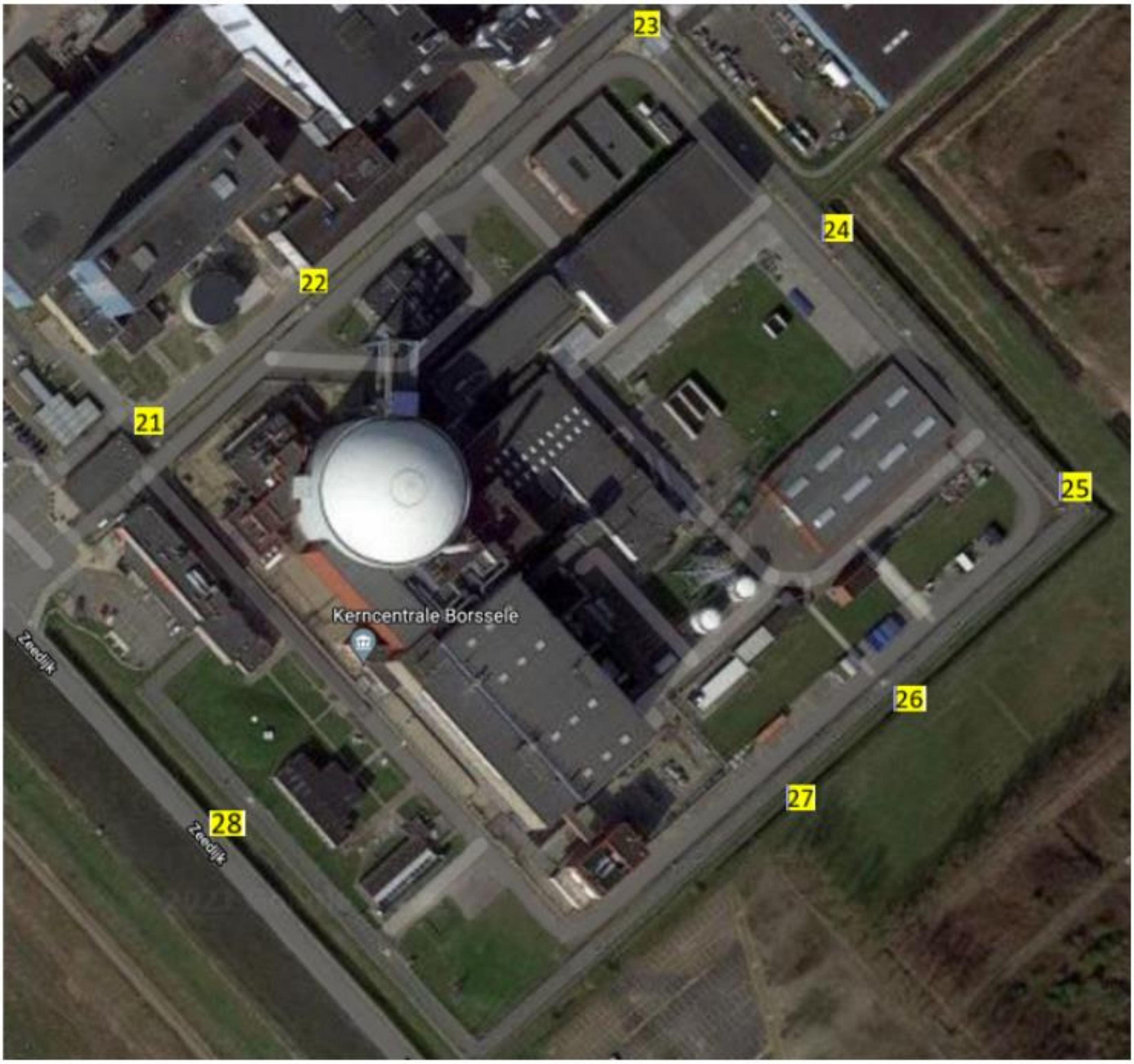


Figure 7-2 Measurement points (yellow) from the RIVM MONET measurement network (figure from (RIVM, RIVM-briefrapport 2023-0315, 2023))

Radiation effects from transport

The RIVM measurement network, with its sensitive detectors, occasionally 'detects' slight increases in the measurements. This is mostly due to the removal of cemented radioactive waste to COVRA and the removal of irradiated fuel elements to Orano's reprocessing plant in La Hague, France. These are the main causes of the occasional increases in the dose on the site boundaries that are measured (inter alia (RIVM, RIVM-briefrapport 2023-0315, 2023).

All deliveries of 'fresh' nuclear fuel to EPZ are done by road. Spent fuel elements are taken by road to COVRA, after which they are transported by train to the reprocessing plant near La Hague in France. Re-usable materials are extracted at the reprocessing plant in La Hague. Residual waste remains after this recycling step, for which there is no application, and this waste is then transported from France to COVRA by train. See the section on storage and the final disposal of radioactive waste for more information on this kind of waste.

Containers of fresh fuel contain less activity than those of spent fuel, because spent fuel contains highly radioactive substances created during the nuclear fission process. Due to the shielding calculated based on this, all transport of waste complies with the legally permissible values for dose rates: the means of transport is permitted to have a dose rate not exceeding 0.1 mSv per hour at a distance of two metres. The maximum for the dose rate directly on the outside of the vehicle is 2 mSv per hour. EPZ demonstrates this for each transport consignment and the competent authority checks all transport of fuel.

7.4.1.4 Storage and final disposal of radioactive waste and decommissioning

As explained earlier in this chapter, all radioactive waste from the nuclear power plant is transferred to COVRA, which is then responsible for its safe management. COVRA is also responsible for providing an ultimate solution in the form of final disposal in the future. Below we outline the types of radioactive waste, their management and the volumes concerned.

Types of waste and their storage above ground at COVRA

Low- and intermediate-level radioactive waste is produced during operations at nuclear power plants. This type of waste includes materials used in nuclear power plants, for instance work clothing and tools. Radioactive waste produced as a consequence of the purification of the cooling water also falls into that category.

This kind of waste is collected in stainless steel barrels, which are then compressed and transferred in a steel barrel. These storage barrels are also packed in a concrete casing for storage at COVRA. COVRA has various buildings used for the above-ground storage of this kind of waste.

EPZ previously decided to have the spent fuel from the nuclear power plant in France reprocessed. Most of the uranium and plutonium is extracted from spent fuel when it is reprocessed according to the standard 'Purex' reprocessing treatment. Some of the remaining material consists of fission products and actinides, which includes minor residues of uranium and plutonium. This waste is mixed with molten borosilicate glass and poured into steel barrels called CSD-V barrels (*Colis Standards de Déchets Vitrifiés*). This waste is known as 'vitrified waste' and is categorised as high-level radioactive waste. It is an extremely stable kind of waste.

At COVRA, the CSD-V barrels are stored in vertical silos, which are continuously (passively) cooled using air flows because of the heat produced by the waste. This is done at a bunker-type building, the high-level radioactive waste treatment and storage building (HABOG). This striking orange building can be used in a modular format, as was recently the case.

The remains of fuel rod casings and fuel elements are also released during reprocessing. This material, consisting mainly of metals, is compacted and placed in steel barrels called CSD-C barrels (*Colis Standards de Déchets Compactés*). The volume, shape and weight of the CSD-C barrels are comparable with those of the CSD-V barrels. The contents, and the way they are stored at COVRA are, however, completely different in nature. Due to the very low heat production of CSD-C barrels, they can be stacked and cooling is not required. The CSD-C barrels are stored in a separate room in the HABOG as high-level radioactive waste at COVRA.

Based on existing contracts, a similar number of CSD-V and CSD-C barrels are delivered back to the Netherlands after reprocessing spent fuel.

Final disposal

As laid down in policy in the Netherlands (Ministerie van Infrastructuur en Milieu, 2016), all radioactive waste stored at COVRA must eventually be placed in a deep geological final repository. Research carried out in the Netherlands has been investigating the potential of geological final disposal of radioactive waste in rock salt and Boom Clay since the 1970s. Many successive research programmes have been working on this, such as the OPERA research programme (COVRA, bezocht maart 2024) and the Rathenau Institute's recent studies (Rathenau Instituut, bezocht maart 2024). This kind of final disposal usually takes place several hundred metres below ground. A final repository is located behind several barriers that separate the waste from the biosphere, i.e. from the human habitat. In particular, the characteristics of the geological formation in which the final repository is located, and the interaction with the waste, are important topics of study. Worldwide, deep geological final disposal is believed to be the safest ultimate destination for radioactive waste.

Volumes of radioactive waste

The RIVM recently (RIVM, RIVM-rapport 2022-0073, 2022) mapped the radioactive residual and waste streams in the Netherlands. In its 2022 Inventory Report (COVRA, oktober 2022), COVRA outlined what certain growth scenarios for nuclear power capacity and the construction of research reactors could mean for the amount of waste that would eventually need to be stored in a final repository.

COVRA has currently taken into account in its policy that EPZ will remain in operation beyond 2034. Therefore in principle there is enough space at COVRA for the storage of the waste from the nuclear power plant (COVRA, oktober 2022). Ten additional years of operation at EPZ could result in 56 m^3 of high-level waste and 700 m^3 of low- and intermediate-level waste, according to COVRA's 2022 Inventory Report. However, if additional large nuclear power plants are to be built, at some point in the future COVRA will need more surface area than it currently has at its disposal.

All plants will eventually have to be dismantled, and Borssele is no exception. Most of the radioactive waste from decommissioning of the nuclear power plant will be low- and intermediate-level waste, according to COVRA (COVRA, oktober 2022). COVRA estimates that this involves a surface area of approximately 1,900 cubic metres at the Borssele nuclear power plant.

7.4.2 Radiological emissions into the air and water

7.4.2.1 Description of exposure pathways and significance

The dose due to radiological emissions via the air and via the surface water during normal operations contributes to the radiation dose in normal operation.

Radioactive emissions into the air

Emissions into the air include emissions of radioactive substances into the atmosphere as well as the radioactivity deposited indirectly on the soil. When calculating the dose effects from these emissions on the population, continuous emissions for 25 years and a dose contribution through the various exposure pathways are assumed (RIVM, 2002), (Nederlandse overheid, 2023). The various pathways are:

- Inhaling gases and aerosols.
- Consuming contaminated foodstuffs (milk, meat and vegetables).
- External radiation due to radioactivity in a passing cloud.
- External radiation due to radioactivity deposited on the ground.
- Ingestion due to consuming self-cultivated vegetables, milk and meat products produced in the surrounding area.

No one lives in the industrial site in the vicinity of the nuclear power plant, nor is any of the produce grown on site consumed. People do, however, live outside the industrial site, and vegetables, milk and meat products may also be produced there.

Radioactive emissions into the surface water

In addition, the radiological consequences of radiological emissions into surface water were determined using a compartment model, in accordance with the ANVS's Regulation on Basic Safety Standards for Radiation Protection (Nederlandse Overheid, 9 januari 2018). The assumption here is that after 25 years of being discharged, the concentration in marine organisms is in equilibrium with the concentration in water. The population is exposed through the following load paths via discharge into surface water (RIVM, 2002), (Nederlandse overheid, 2023):

- Ingesting seafood (marine fish, mussels and shrimps).
- Inhaling sea spray.
- Inhaling end sedimentation.

As a general rule, of these three load paths, the consumption of sea food (seafood, mussels, shrimps) is responsible for contributing the largest dose for the population in the Netherlands.

Monitoring discharges

Permit holders of nuclear power plants monitor all discharges and report on this to the ANVS. Samples are also taken periodically at fixed locations in the immediate vicinity and at the more distant points of the plant. In addition, RIVM checks all these measurements on behalf of the ANVS. This is discussed in greater detail in the rest of this section.

7.4.2.2 EPZ emission data (in Bq) compared to discharge limits

Year on year, the nuclear power plant continues to meet the requirements for discharges into the air and surface water. This is illustrated in the two tables below that, in addition to the annual limit, give the percentage of the current discharge compared to the applicable annual limit for five consecutive years (2018 to 2022) in each case. The data is from Borssele nuclear power plant's environmental reports that have been given to ANVS.

Table 7-5 Discharge into the air, discharge limits and percentage of the annual limit that was discharged during five consecutive years (EPZ, PO-N08-31, maart 2019) (EPZ, PO-N08-31, maart 2020) (EPZ, PO-N08-31, maart 2021) (EPZ, PO-N08-31, maart 2022) (EPZ, PO-N08-31, maart 2023)

Assessment criteria	Annual limit	% in 2018	% in 2019	% in 2020	% in 2021	% in 2022
Noble gases	500 TBq	0.060	0.13	0.11	0.081	0.14
Halogens	50 GBq	0.22	0.003	0.002	0.006	0.005
Aerosols	500 MBq	< det*	< det*	< det*	< det*	< det*
Tritium	2 TBq	10	10	11	15	15
Carbon-14	300 GBq	46	42	46	41	41

(*) lower than the detection limit

The discharge of the radionuclides, tritium and carbon-14, through the ventilation shaft depends on the energy production in the reactor and its discharge cannot be influenced.

Table 7-6 Discharge into the surface water, discharge limits and percentage of the discharge limit that was discharged during five consecutive years (EPZ, PO-N08-31, maart 2019) (EPZ, PO-N08-31, maart 2020) (EPZ, PO-N08-31, maart 2021) (EPZ, PO-N08-31, maart 2022) (EPZ, PO-N08-31, maart 2023)

Assessment criteria	Annual limit	% in 2018	% in 2019	% in 2020	% in 2021	% in 2022
Beta and gamma emitters (excluding tritium)	200 GBq	0.020	0.020	0.007	0.019	0.015
Tritium	30 TBq	17	20	22	15	18
Alpha emitters	200 MBq	< det*	< det*	< det*	< det*	< det*

(*) lower than the detection limit

On the ANVS' instructions, RIVM monitors the measurements for radioactivity in waste water and ventilation air taken by the nuclear power plant eight times a year. RIVM found that most of the measurements taken by the plant are consistent with its own results. See, for instance, the RIVM 2022 report (RIVM, RIVM-briefrapport 2023-0385, 2023), for the period 2020-2021 (RIVM, RIVM-briefrapport 2021-0158, 2021) and 2019 (RIVM, RIVM-briefrapport 2020-0021, 2020).

7.4.2.3 Consequences of doses

For the Borssele nuclear power plant's safety report (EPZ, versie 1, november 2015) the doses due to discharges were calculated (the dose consequences). The safety report is an important document required under the plant's permit pursuant to the Nuclear Energy Act. Regarding doses due to radioactive discharges, calculations were made based on discharges within the scope of the permit limits and actual discharges averaged over the period from 2003 up to and including 2012. Because the discharges since then have not increased, this is still the representative calculation.

The exposure pathways examined include external irradiation through radioactive substances in the air and on the ground, inhalation of radioactive substances and absorption through the oesophagus (ingestion) through consumption of agricultural and fishery products and drinking water. Maximum individual doses were calculated for a reference person, being an adult in the population who receives the highest individual dose.

If discharges were to be made at the level of the permit limits, a reference person would receive a dose of 0.0025 millisieverts per year as a result of the discharges. That is less than one thousandth of the average radiation dose received in the Netherlands from all radiation sources combined. However, at the actual average discharge during the period under review, a maximum of about 0.0002 millisievert was received as a result of the discharges, which is less than one hundred thousandth of the normal annual dose from all sources.

7.4.2.4 Radioactivity measurements in the vicinity of the nuclear power plant

Measurements and counterchecks

The Borssele nuclear power plant engages the Nuclear Research and Consultancy Group (NRG) to take samples of the grass, water, air dust, sediment and seaweed. Soil samples are also analysed each year. The NRG then determines the radiation activity in these samples. Gamma emitters, gross alpha and gross beta activity are analysed.

RIVM carries out the counterchecks of the NRG's measurements on behalf of the ANVS, using its own measurements and comparing them with the NRG's results. As a general rule, the RIVM's data and the NRG's data correspond. Only a slightly higher level of radioactivity was measured in the sand near the cooling water outlet. For the rest, the NRG and RIVM both report measurements below or at the detection limit, low levels of natural radioactivity, or traces of caesium-137. The latter is a known surface contamination across the Netherlands and it is due to the 1986 accident at the Chernobyl nuclear power plant in Ukraine.

A recent RIVM report (written in English) as part of the countercheck, covers the period from 2019 to 2020 (RIVM, RIVM letter report 2021-0078, 2021). It reports that there is agreement between the NRG and RIVM. It also states that there was no radioactive contamination that could be traced back to the nuclear power plant. In 2019, some tritium was found in the water downstream of the plant, but its origin is difficult to determine because of the upstream nuclear power plant at Doel (in Belgium). No tritium was found in 2020.

Given the results of the measurements, the nuclear power plant's operations are unlikely to have any consequences for biota in the vicinity of the power plant.

See Figure 7-3 for a map showing the measurement points in the vicinity of the Borssele nuclear power plant.

Meetpunten omgeving kernenergiecentrale Borssele

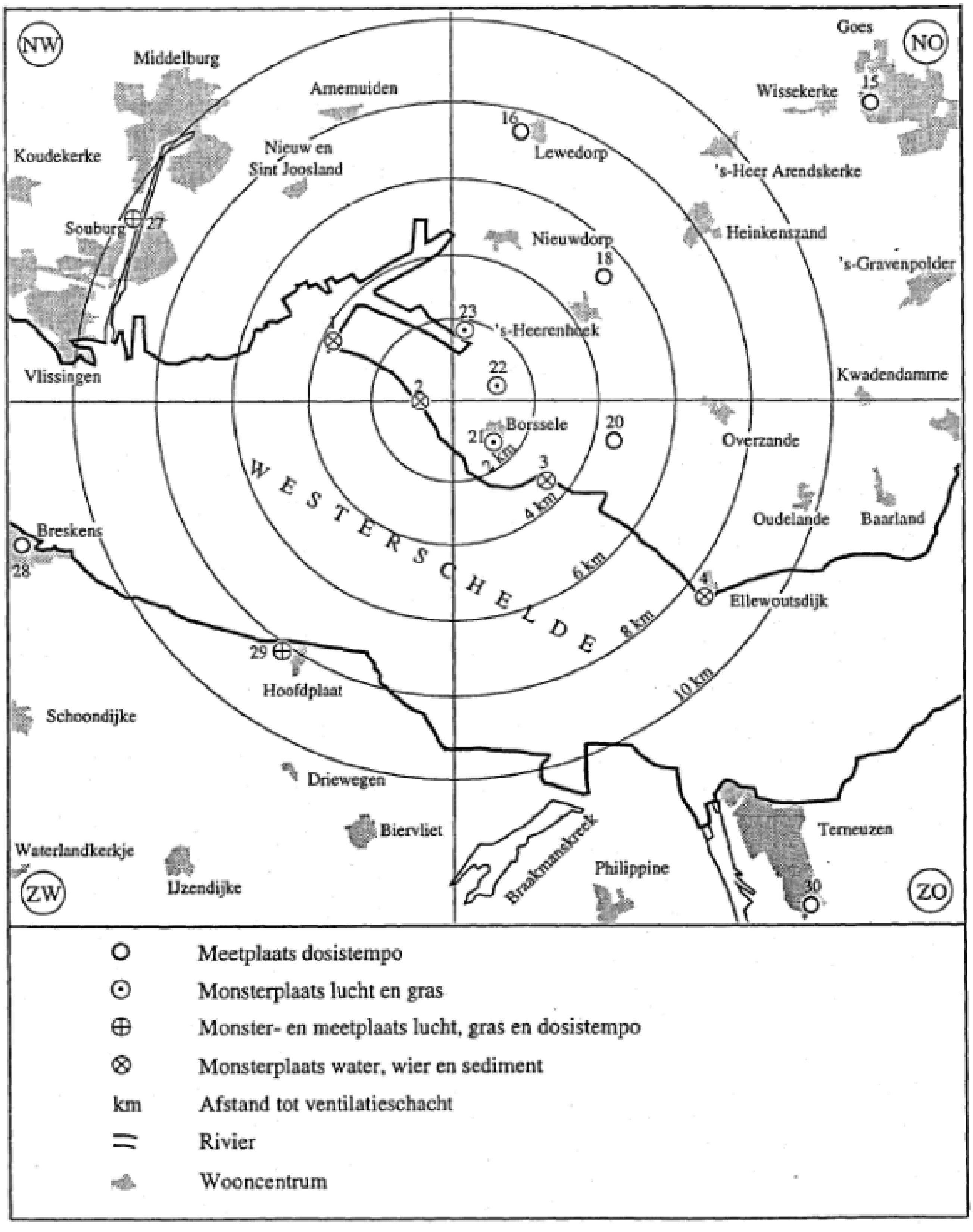


Figure 7-3 Overview of most sampling points around the Borssele nuclear power plant. Figure taken from Borssele nuclear power plant's 2022 Annual Environmental Report

7.4.3 Transboundary effects

The potential significant adverse effects on the environment in another country as a result of a proposed activity also have to be determined. If this is the case, the requirements of the Dutch Environmental and Planning Act [*Omgevingswet*] (Article 16.42b) and the Dutch Environmental and Planning Decree [*Omgevingsbesluit*] (Article 11.22-11.26) have to be implemented. For the proposed activity, the extent to which the effects that occur for the radiation protection aspect take place beyond the Netherlands' borders has therefore been assessed. The closest countries are Belgium, England and Germany which are at least about 16, 157 and 156 km, respectively, from the Borssele nuclear power plant to the national border. These effects are assessed per aspect.

Staff exposed and not exposed in the course of their work

The laws of the Netherlands apply to all employees, regardless of where they live. This means that the transboundary effects do not apply.

Population

The closest national border with Belgium is around 16 km away. Below we describe the impact of radioactive emissions (air and water) and direct radiation from the nuclear power plant.

Gaseous emissions can occur in the atmosphere during normal operations. These emissions are carried and diluted by the wind. The extent to which this occurs and the direction the emissions are blown depend on the strength of the wind and the direction it takes. As noted earlier in this chapter, the emissions comply with the applicable discharge limits and the maximum radiation exposure of the population is well within the legal criteria. The radiation dose lessens as the distance increases. As a result, the transboundary impact is significantly lower and, as a result, it remains below the legal criteria. There is therefore no significant impact on Belgian territory, and the impact on countries further away from the Netherlands is even less significant. As a result, the transboundary effects due to emissions into the air can be ruled out.

There are also emissions into the Western Scheldt. As noted earlier in this chapter, these emissions comply with the applicable discharge limits and the maximum radiation exposure of the population is well within the legal criteria. These emissions can reach the nearest land border via the Zeeland-Flemish coast. The transport route of radionuclides in the Western Scheldt and North Sea is complex, and the dispersion of liquid emissions in water is more localised and subject to local conditions. Given the distance of the nuclear power plant from the Belgian North Sea coast, the doses in Belgium due to liquid emissions will be lower than those emissions calculated for the reference person in the Netherlands. The transboundary effect is therefore negligible.

As far as direct radiation is concerned, the dose rate decreases as the distance increases. Based on a point source, the dose rate decreases quadratically with distance. As noted earlier in this chapter, the maximum permissible effective dose for persons outside the nuclear power plant at the site boundary is 0.010 millisieverts per year, but the dose determined in practice is usually around 0.001 millisieverts per year. At a distance of more than 16 kilometres, this effective dose will no longer be detectable relative to naturally occurring background radiation. The transboundary effect is therefore negligible.

7.5 Extrapolation of the environmental situation

Extrapolating the environmental situation identifies where possible future (after 2033) problem areas may be an issue, and therefore where there may be gaps in knowledge which will have to be investigated further in Phase 2. This chapter only examines issues relevant to the radiation protection aspect.

As far as radiation protection as discussed in Section 7.4 is concerned, only the construction of new nuclear power plants may be a relevant development that may affect the future environmental situation after 2033. When planning to build new nuclear power plants, it is up to those advocating for them to demonstrate that their impact on the environment as far as radiation protection is concerned will be sufficiently low and will comply with the legislation in question.

If the Borssele nuclear power plant continues to operate after 2033, it is expected that, in a similar way to now, all legal requirements regarding radiation protection, including those concerning emissions into the air and water, will continue to be met.

7.6 Outlook for EIA Phase 2

During EIA Phase 2, it will be clear whether any physical adjustments to the nuclear power plant are necessary. No bottlenecks and/or knowledge gaps have been identified as environmental focal points for EIA Phase 2.

8 Nuclear safety

8.1 Introduction

The fundamental objective for the safety of all nuclear facilities is to protect people (staff at the facility and external personnel, the surrounding population and employees working at neighbouring companies) and the environment from the harmful effects of ionising radiation.

The safety level of a nuclear installation is determined by the safety requirements on which its design, and any later design improvements, are based (the design basis) and its mode of operation. Due to the specific nature of a nuclear plant such as the Borssele nuclear power plant the basis premise on which the design rests is that general environmental safety must be ensured under all reasonably conceivable conditions. In practice, this means demonstrating, using deterministic and probabilistic analyses, that the design of the plant safeguards nuclear safety functions. It also means demonstrating, based on radiological analyses, that the consequences for the environment of potential accident scenarios are controlled. Because all plants deteriorate over time, and this can affect nuclear safety, the way the Borssele nuclear power plant manages ageing has been added in this EIA.

The consequences of the potential accident scenarios mentioned are subject to legal criteria laid down in legislation and regulations (Section 8.2), which are set out in greater detail in Section 8.3. Section 8.4 describes the current situation of safeguarding environmental safety under all reasonably conceivable accident scenarios, as well as the current ageing management. Of these subjects, the extrapolation of the environmental situation after 2033 is set out in Section 8.5. Environmental focal points that may have to be dealt with in the next phase (EIA Phase 2) are described in Section 8.6.

8.2 Relevant policy frameworks

This section discusses the legislation and regulations and the policy framework for nuclear safety (Table 8-2). To clarify the policy framework, an explanatory introduction is given based on the safety objective, safety functions and the layered safety concept.

8.2.1 Safety objectives and functions

Safety comes first when operating a nuclear power station. This means that the protection of people and the environment against the harmful effects of ionising radiation throughout the entire service life of a nuclear reactor must be adequately safeguarded. The service life[37] comprises the design, construction, commissioning, operation and, ultimately, shutting down and decommissioning of the plant. In essence, in order to be able to meet the objectives, the following three safety functions must be fully met:

1. The control of the reactivity.
2. The removal of heat from the reactor and nuclear fuel storage.
3. The isolation of radioactive materials.

These three safety functions apply to all phases of a nuclear reactor's service life and are rooted in the layered safety concept. To guarantee these safety functions, operating a nuclear reactor requires measure to be taken:

- To control human exposure to ionising radiation and the discharge of radioactive materials or (irradiated) nuclear fuel into the environment.
- To reduce the likelihood of initiating events that could lead to loss of control of the nuclear reactor core, nuclear chain reaction, radioactive sources or other sources of ionising radiation.
- To mitigate the consequences of these initiating events should they occur.

[37] The service life comprises the design, construction, commissioning, operation, shutdown and decommissioning. As opposed to this, the operating life includes the operating life.

In this respect, an initiating event is defined as an incident which may reasonably be expected to occur and which, if the specially designed safety systems function properly, will result in foreseeable operating consequences or accident conditions that can cause contamination or environmental exposure (Nederlandse Overheid, 4 sept 1969).

8.2.2 The layered safety concept

The nuclear safety of nuclear power plants is based on the concept of layered safety, whereby accidents are prevented, failing which the consequences are kept to a minimum. The concept comprises a concerted action of structural, technical and organisational provisions. Several levels of protective measures ensure the safety of the reactor under abnormal circumstances and accident conditions. The objective of each safety level is to prevent all potential human and component failures (prevention) or limit the radiological consequences of such failures as much as possible (control, mitigation) using the available resources. For successive safety levels with corresponding operating states, please refer to Table 8-1.

Under normal operations, the plant is at Safety Level 1. Prevention of malfunctions in daily operations is the main objective of this level. At the following levels, anticipated operational occurrences (also known as abnormal operations) (Safety Level 2), accidents not involving a core melt (Safety Level 3) and accidents involving a core melt (Safety Level 4) are controlled. Should significant discharges of radioactive substances into the environment nevertheless occur, measures aimed at limiting the impact on humans, animals, plants and property (Safety Level 5) are taken.

Dose limits have been set for the incidents in the various safety levels (see Section 8.3).

Table 8-1 The layered safety concept

Level of layered safety	Associated plant condition categories	Objective	Essential resources	Radiological consequences
Safety Level 1	Normal operation	Prevention of abnormal operation and failures	Conservative design and high quality in construction and operation, control of main plant parameters within defined limits	Operating limits for discharge under the permit
Safety Level 2	Anticipated operational occurrences	Control of abnormal operation and failures	Control and limiting systems and other surveillance features	
Safety Level 3	Safety Level 3a: postulated single events	Control of accident situations to limit radiological discharge and prevent escalation to core melt conditions	Reactor protection system, safety systems, accident procedures	No off-site radiological impact or only minor radiological impact
	Safety Level 3b: postulated multiple failure events		Additional structures, systems and components and accident procedures	
Safety Level 4	Postulated core melt accidents (short and long term)	Control of accidents with core melt to limit off-site releases	Complementary safety features, accident procedures	Limited protective measures in area and time

Level of layered safety	Associated plant condition categories	Objective	Essential resources	Radiological consequences
Safety Level 5	Significant releases of radioactive material	Limiting radiological consequences	Off-site emergency response Intervention levels	Radiological off-site consequences requiring protective measures

8.2.3 Barrier concept

The barrier concept is part of the layered safety concept. The objective of the barrier concept is to isolate radioactive materials and (irradiated) nuclear fuels in the plant. The concept is based on the presence of several successive physical barriers and retention functions. Should the one barrier fail to function properly, the next one will ensure the material is isolated.

The number and types of barriers is determined inter alia by the type of nuclear reactor, its configuration and its capacity. The fuel rod cladding is also a barrier. Retention functions are measures taken or provisions made to contain radioactive materials. This can be done, for instance, by filtering the air, covering radioactive material with water, controlling the airflow flow by maintaining negative pressure, having building seals, containers, etc (see Section 3.1.1 for a description of the situation at the Borssele nuclear power plant).

From a safety perspective, it is important that the barriers operate independently of each other. This means that if there is a hazardous situation or an accident, a barrier must not fail simply because another barrier fails. Should any of the barriers fail despite this, and radioactive materials are released as a result, the retention functions are there to stop or temporarily contain those materials.

8.2.4 Legal and policy frameworks

The table below gives the legal and policy frameworks at a national and international level.

Table 8-2 Legal and policy frameworks for nuclear safety

Policy, legislation and regulations	Contents and relevance
The Dutch Nuclear Energy Act [*Kernenergiewet*] (Nederlandse Overheid, 21 febr. 1963)	In the Netherlands, all operations involving ionising radiation fall under the regime of the Nuclear Energy Act [2], which provides the basis for protecting the population, the environment, workers and patients from the adverse effects of ionising radiation. ¿ The Act does this by requiring that a permit be obtained and for most actions involving sources of ionising radiation. The Act is set out in greater detail in the Nuclear Facilities, Fissionable Materials and Ores Decree, the Decree on Basic Safety Standards for Radiation Protection, and the associated regulations. The Borssele nuclear power plant currently holds a permit under the Act for operating a facility in which nuclear energy can be released (Section 15(b)); holding nuclear fuel (Section 15(a)), holding, applying and disposing of radioactive substances (Section 29(1)) and performing operations with devices (Section 34).
Nuclear Facilities, Fissionable Materials and Ores Decree ('the Decree') (Nederlandse Overheid, 4 sept 1969)	This Decree includes general rules regarding the provision of information when applying for a permit under the Act and the criteria under which an application can be refused, for instance, if the radiation dose does not meet the legal limits.
Decree on Basic Safety Standards for Radiation Protection (Nederlandse overheid, 23 oktober 2017) and its associated regulations, including the ANVS's Regulation on Basic Safety Standards for Radiation Protection (Nederlandse Overheid, 9 januari 2018)	This Decree on Basic Safety Standards for Radiation Protection sets rules for the protection of the population, the environment, the workforce and patients against the harmful consequences of ionising radiation. The decree is based on Council Directive 2013/59/Euratom, which implements the recommendations of the International Commission on Radiological Protection (ICRP). As a result, the legislation is in line with the latest scientific insights.
Regulation on Safety of Nuclear Facilities (Nederlandse Overheid, 6 juni 2017)	This is a ministerial regulation providing for nuclear safety at nuclear plants and is subordinate to the Nuclear Energy Act. The regulation implements Directive 2014/87/Euratom of 8 July 2014.
IAEA guidelines	The International Atomic Energy Agency (IAEA) publishes documents concerning nuclear safety, which are used mainly as guidelines.
Convention on Environmental Impact Assessment in a Transboundary Context, as provided for in the Dutch Environmental Management Act [*Wet Milieubeheer*] (Nederlandse Overheid, 23-10-2017)	This is a UN treaty on environmental impact assessments in a transboundary context.

8.3 Criteria

In this section, the criteria are based on prevailing legislation and regulations.

The area studied in terms of nuclear safety is defined by the sites where the radiation dose due to accidents is greatest. For direct radiation, this is the area directly adjacent to the Borssele nuclear power plant site boundary. As far as radioactive discharge into the air and water is concerned, this depends heavily on the resulting dispersal, for instance due to the weather.

8.3.1 Radiological requirements in postulated design basis accidents

Article 18 of the Nuclear Facilities, Fissionable Materials and Ores Decree lays down several mandatory and potential grounds for refusing an application for a permit under Section 15(b) of the Nuclear Energy Act. The grounds for refusal in Article 18(2)(a) of the Decree concerns the limits for postulated initiating events. This concerns events that lead to accidents that were taken into consideration in the design of the plant.

A dose limit, which depends on the likelihood of the event happening, has been formulated for these postulated events. This concerns discharges during normal operations, foreseeable malfunctions and accidents.

Safety Levels 1 and 2: dose limits

The basic principle underlying the Decree on Basic Safety Standards for Radiation Protection is that radiation exposure from operations should be kept as low as reasonably possible.[38] The limit for the effective dose for the population is 1 mSv per calendar year (see Chapter 7 Radiation protection during regular operations). That same limit applies to staff that would normally not be exposed to radiation during their work. Special requirements and a limit of 20 mSv per calendar year apply to those who are exposed to radiation while working.

Safety Level 3: dose limits

Accidents that do not involve a core melt must have no or only a limited radiological impact on the environment. To this end, dose limits are linked to the frequency with which accidents can occur without resulting in a core melt.. The more likely an accident is, the lower the dose due to the accident may be. Table 8-3 gives the legal dose limits for events as stipulated in the Decree (Article 18(2) (Nederlandse Overheid, 4 sept 1969). The Decree (Article 18(2)) also gives the criterion for the maximum thyroid dose of 500 mSv.

Table 8-3 Event frequencies and dose limits for postulated accidents

Event frequency F per year	Maximum permissible dose allowed per person	
	Persons aged 16 years and over	Persons under the age of 16 years
$F \geq 10^{-1}$	0.1 mSv[39]	0.04 mSv
$10^{-1} > F \geq 10^{-2}$	1 mSv	0.4 mSv
$10^{-2} > F \geq 10^{-4}$	10 mSv	4 mSv
$F < 10^{-4}$	100 mSv	40 mSv
	Thyroid dose ≤ 500 mSv	

8.3.2 Permissible risk as a consequence of postulated beyond design basis accidents

Safety Level 4

The preconditions for safety level 4 require that core melt accidents that could lead to premature and/or large-scale discharges are practically ruled out. The objective here is that, if a core melt accident occurs, only protective measures that are limited in time and scope need to be taken and that there is enough time to implement them. All reasonably possible solutions that can reduce the potential exposure of employees, the general public and the environment must be implemented. In a core melt accident, the containment (the enclosing, sealed building) is the main barrier for protecting the environment from radioactive material. That is why it is essential to keep the containment intact. With this in mind, the plant has to be designed in such a way that any discharges during a core melt are kept to an absolute minimum. For this, the criteria as summarised in Table 8-4 must be met. The Nuclear Facilities, Fissionable Materials and Ores Decree (Article 18(3)) states that the risk analysis for the individual (site-specific) risk must demonstrate that the probability that a person, who is unprotected and permanently outside the site in question, dies as a result of an accident is less than 10^{-6} per year (see Table 8-4). For the group risk, this risk analysis must demonstrate that the probability that a group of at least ten persons present outside the facility in question will be direct fatalities of an accident, is less than 10^{-5} per year (or a probability for n times more direct fatalities).

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[38] Decree on Basic Safety Standards for Radiation Protection, Article 9.1(2)(a).

[39] The sievert (symbol Sv) is the unit for the equivalent dose of ionising radiation to which a human is exposed in a given period and is equal to 1 J/kg. The sievert depends on the biological effects of radiation. A millisievert (mSv) is one thousandth part of a sievert.

Table 8-4 Permissible risk for those living in the vicinity as a result of beyond design basis accidents

Type of risk		Permissible risk
Individual (site-specific) risk		≤ 10^{-6} per year
Group risk	10 casualties	≤ 10^{-5} per year
	100 casualties	≤ 10^{-7} per year
	1,000 casualties	≤ 10^{-9} per year

Safety Level 5

For the last (extremely unlikely) safety level, radiological effects may occur off-site that require protective measures. These kinds of measures may include iodine prophylaxis and sheltering or evacuating nearby residents within a given zone around the plant. Such measures are carried out under the guidance of the external emergency response organisation, which includes the ANVS and the Safety Region. Management of radiation accidents is organised at national and regional level in line with the National Radiation Crisis Plan (Ministerie van Infrastructuur en Waterstaat, april 2021). This plan describes the crisis strategy and collaboration and connection with the relevant public and private partners, the knowledge and advisory structure and international organisations. The plan sets the framework and is overarching in nature. It contains individual, more operationally detailed plans, scenarios and roadmaps for the participating organisations, such as the EPZ. Because radiation accidents can cross borders, the European Union countries have agreed that the countries involved will alert and inform one another as soon as possible.

8.4 Description of the current situation

This section describes the current situation with regard to ensuring safety for the area surrounding the Borssele nuclear power plant under all reasonably conceivable accident situations (Section 8.4.1) and EPZ's current approach to its management of ageing (Section 8.4.2).

8.4.1 Emergencies and accident scenarios

As part of the description of the Borssele nuclear power plant's current situation with regard to emergencies and accident scenarios, the following sections are covered below:
- Managing design basis accidents (in accordance with the Nuclear Facilities, Fissionable Materials and Ores Decree, Article 18(2)).
- Managing beyond design basis accidents (in accordance with the Nuclear Facilities, Fissionable Materials and Ores Decree, Article 18(3)).
- Transboundary effects.

8.4.1.1 Managing design basis accidents

The potential hazard of a nuclear power plant is mainly determined by the amount of radioactive material contained in the plant. Most of the radioactivity in the plant is in the reactor core. The fresh nuclear fuel contains only a small amount of radioactivity, but a significant amount of radioactivity is formed in the fuel when the reactor is operating. This radioactivity basically stays isolated inside the fuel elements. Radioactive materials are also created through the activation of construction materials and of the main coolant.

For nuclear power plants, it has to be demonstrated that all possible accidents that could reasonably happen can be controlled and that the consequences, such as any radioactive discharge, are within the legal criteria. These accidents can be triggered by internal events, such as an internal power outage or fire, and from external causes prompting an accident, such as flooding or an earthquake. To be able to demonstrate this, the design of the nuclear power plant is subjected to a plethora of analyses. This includes strength calculations and observations of the neutron physics behaviour of the reactor core. Accident analyses are used to demonstrate that the potential consequences of postulated initiating events (design basis accidents) are adequately controlled by the design. These accident analyses are generally divided into thermo-hydraulic analyses (the way the plant is behaving) and radiological analyses (consequences for the environment).

Thermal-hydraulic analyses

For thermal-hydraulic analyses, the reactor system is 'converted' into a computer model. A calculation is then done of how the plant will respond to the postulated initiating events. The objective of this kind of analyses is to demonstrate that the consequences of the postulated initiating events will be controlled.

When deciding which representative initiating events would be analysed, a basic list was used based on the IAEA's international guidelines. Installation-specific characteristics were added to the list. Not all these initiating events have been analysed in detail; only the representative (covered) initiating events using the most stringent protection target of the covered initiating events. This is done according to the applicable regulations and using modern calculation software suitable for that purpose. Conservative basic principles and assumptions, as well as modelling of the plant and processes, are the underlying premise in this respect. Assumptions and basic principles include for instance:

- Operations with an increased capacity.
- Ignoring the reactor's first shutdown alarm.
- The most effective control assembly is not in the core.
- High or low decay heat.
- Failure of the system that has the most positive effect on the course of the accident.
- Additional single failure of a component, which plays a role in controlling the accident.
- Unavailability of the operating systems.
- Outage of the normal power supply (emergency power situation).

Where relevant, accident situations have been considered for non-power operations as well as for power operations.

Using thermal-hydraulic analyses, it is demonstrated that the plant can be brought into and maintained in a safe condition after all postulated initiating events and that the relevant safety objectives are safeguarded. These analyses and their results have been included in the Safety Report (EPZ, 2015) as it was used to obtain the permit for the Borssele nuclear power plant pursuant to the Nuclear Energy Act.

Radiological analyses

As a general rule, design basis accidents do not trigger the discharge of radioactivity into the environment. This is not surprising given that the design is based on managing design basis accidents and, with that, the isolation of radioactivity. That said, some design basis accidents may result in discharges that may exceed the emissions from normal operations. Based on radiological analysis, it must be demonstrated that the effects of this kind discharge are below acceptable limits.

Radiological analyses calculate the consequences of a discharge on the area surrounding the Borssele nuclear power plant, as well as the dose resulting from external radiation from radioactivity located in the reactor building. The amount of radioactivity discharged is determined, and a dispersion model is used to calculate how this activity spreads in the environment. Depending on the spread of radioactivity, the impact on people in the vicinity is calculated. These consequences are expressed as two values. First, the effective dose (E), being the measure of the effect of the total amount of radiation that the human body absorbs over a given period of time. And secondly, the thyroid dose (H_{th}), which refers specifically to the amount of radiation absorbed by the thyroid gland (this is mainly due to the absorption of radioactive iodine).

The radiological analyses were conducted in accordance with guidelines in the Netherlands: Level 3 PSA (ANVS, Maart 2020)[40]. Figure 8-1 presents a diagram of the exposure pathways for radiological discharge into the air, namely:

- Inhalation.
- External radiation due to radioactivity in the passing cloud.
- External radiation due to radioactivity deposited on the ground.
- Ingestion due to consuming self-cultivated vegetables, milk and meat products produced in the vicinity of the Borssele nuclear power plant.

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40 We refer to the current 2020 PSA Guidelines, however, the existing radiological analyses are still based on a previous version of this guideline (PSA: probabilistic safety evaluation) Partly in the context of the recent 10-yearly safety review, EPZ is in the process of updating the analyses to the latest version.

Accidental discharges into surface water or sewers (contaminated water used to fight the fire) were only considered if they could contribute significantly to the risk. The reason for this is that, in an accidental discharge to surface water, the immediate lives of individuals are not threatened, whereas in an airborne discharge they are, for instance due to inhaling radioactive substances in a residential zone. Indirect exposure is theoretically possible, for example through contaminated drinking water and food (such as fish), but this exposure can be effectively and relatively easily reduced by taking measures, such as by taking fish off the market. If there is an accidental discharge into the air, this will in most cases dominate the risk.

A significant number of the parameters for exposure are policy based (ANVS, Maart 2020). These include, for example, the standard dietary choices to be applied in the analysis, the respiratory rate, consuming drinking water, the region from which food products are obtained and the dose coefficients to be used.

For the committed effective dose for children, a period of 70 years is applied, and for adults this period is 50 years.

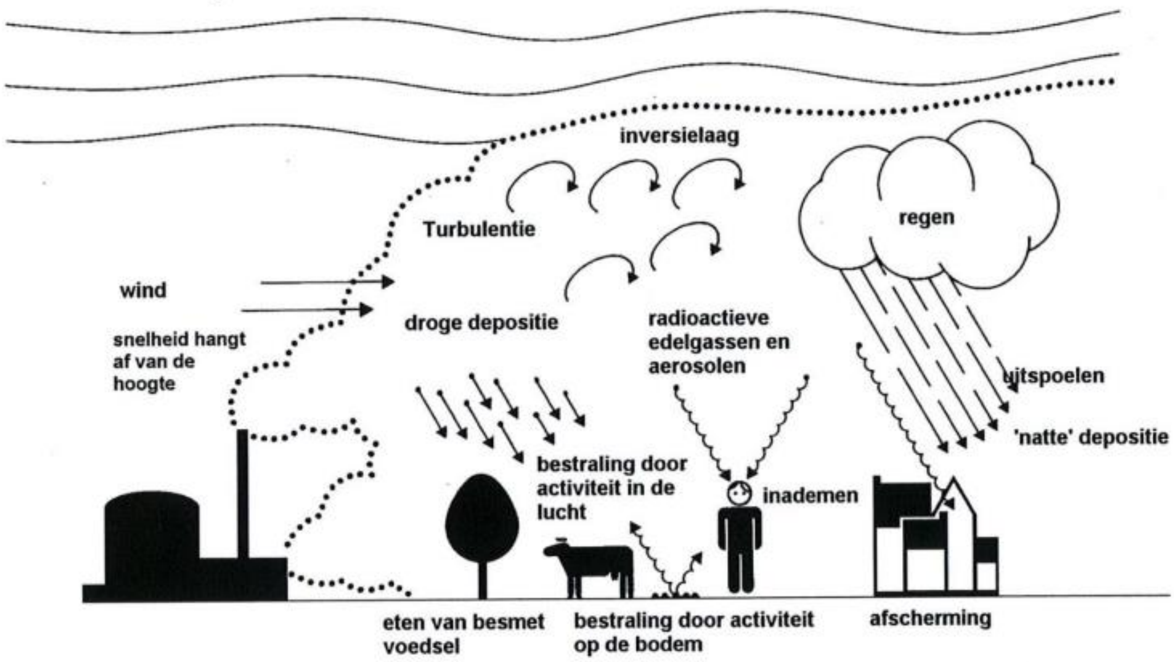


Figure 8-1 Schematic representation of the exposure pathways to humans and the environment of radiological discharge into the air

The results of the thermo-hydraulic and radiological analyses were reported in the Safety Report (EPZ, 2015), as used to obtain the permit for the Borssele nuclear power plant pursuant to the Nuclear Energy Act. With these results, the Safety Report demonstrates that the relevant legal criteria are met for the design basis accidents under consideration (see Table 8-3). In the process, it demonstrated that the effective dose and thyroid dose are in all cases well below the criteria where the maximum occurs directly at EPZ's site boundary. For greater distances, the margin compared with the criteria increases accordingly.

8.4.1.2 Managing beyond design basis accidents

In addition, nuclear power plants are also obliged to demonstrate that the permissible risk to local residents from beyond design basis accidents meets the applicable criteria. To demonstrate this, it is customary at an international level to carry out a probabilistic safety evaluation (PSA: probabilistic safety evaluation). The EPZ also conducts a similar PSA.

A PSA of a nuclear power plant is a systematic investigation into the likelihood of accidents occurring that may lead to reactor core damage and the impact on the surrounding area. An investigation of this kind deals with accidents that could lead to damage (including a meltdown) of the reactor core as well as leakage or failure of the containment building. The scope includes events that, due to internal causes (such as component failure or human failure) or external influences (such as an earthquake or flood), could lead to a core melt. For these kinds of accidents, the consequences of radioactive discharges, which may occur in these accidents, are calculated.

The PSA starts with an inventory of the possible process malfunctions. As was the case with the accident analysis of the design basis accidents outlined above, this is done by postulating initiating events. Of all the potential initiating events, only those selected may lead to core damage. All possible accident scenarios that could lead to radioactive discharges are determined. With this in mind, PSAs are subdivided into three levels:

- Level 1: Determining the overall probability of severe damage or melting of the reactor core.
- Level 2: Determining the pressure on the containment building and the possible loss of its function. In the process, the specific characteristics of the resulting accidental discharges are accurately determined.
- Level 3: Based on the accident discharges determined in the Level 2 analysis, the radiological implications for humans and the environment are determined based on the dispersion and deposition of radioactive substances in the environment, in accordance with guidelines in the Netherlands of Level 3 PSA (ANVS, Maart 2020). For humans, the consequences are subdivided into the acute impact on health and the consequences that occur later. Together with the likelihood of these health hazards occurring, this forms the risk.

Criteria for site-specific and group risks have been determined in the risk policy in the Netherlands. The criterion for (site-specific) individual risk consists of adequately protecting individual members of the population from the risk of a fatal impact on health due to radiation. For the purpose of determining individual risk and in line with risk policy in the Netherlands, the most vulnerable group is considered, namely the cohort of one-year-old children.

The population as a whole also has to be protected to an acceptable level against the risk of social disruption due to an accident; this is a group risk criterion.

Individual risk

Individual risk is calculated by combining the risk of death due to short- and long-term effects. The individual risk is for the critical cohort (one-year-old children) determined as a function of the distance from the Borssele nuclear power plant. The assumption for this is that only the area outside the site boundary (which is at least 350 metres from the plant discharge point) is inhabited. In addition to this, the implementation of the legally required food measures were assumed when calculating individual risk. These measures involve taking agricultural products containing iodine, strontium, caesium and α-emitters in excess of established limits off the market. Other potential protective measures were not taken into consideration.

The results of the PSA were reported in the Safety Report (EPZ, 2015), as used to obtain the permit from EPZ pursuant to the Nuclear Energy Act. In line with these results, the total maximum individual risk per year (for one-year-old children) of all source terms combined is presented below in Figure 8-2 as a function of the distance from the power plant. The figure shows that the individual risk reduces as the distance to the Borssele nuclear power plant grows.

Figure 8-2 shows that the values for individual risk for all distances from the nuclear power plant remain well below the legal criterion of 10^{-6} per year pursuant to the Nuclear Facilities, Fissionable Materials and Ores Decree (see Table 8-4). Applying the ‘evacuation’ countermeasures and ‘iodine dispensing’ in addition to food measures can reduce individual risk further.

Figure 8-2 gives the results for the situation in 2015 and thereafter, after implementing safety-enhancing measures based on the ten-year assessment over the period from 2003 to 2012 (10EVA13) and the stress test (CSA: complementary safety margin assessment). Both situations adequately represent the current situation because the results of both situations differ only slightly, and there have been no adjustments after that time that could cause significant deterioration.

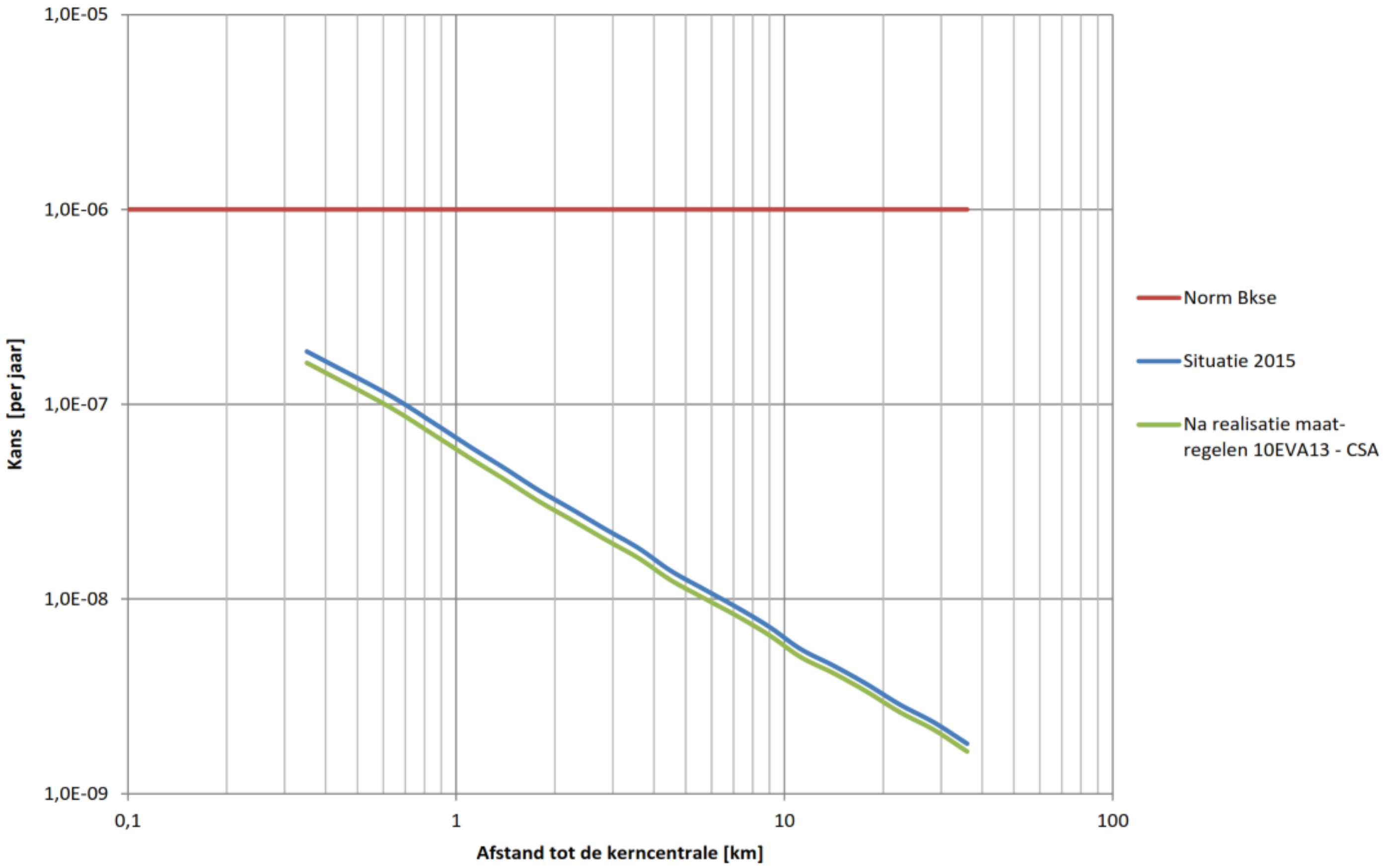


Figure 8-2 Individual risk for the critical cohort of children due to the Borssele nuclear power plant (EPZ, 2015)

Group risk

The results of the group risk calculations are presented as a 'complementary cumulative frequency distribution' (CCFD). This kind of graph shows the probability of the associated impact being exceeded. Figure 8-3 presents the group risk as calculated for the Borssele nuclear power plant in the Level 3 analysis. The figure shows the probability (per year) of a given number of people in the population falling victim as a result of the potential accident scenarios under consideration. The criterion for the maximum permissible group risk is also indicated in the figure by way of a sloping line. The group risk calculation assumes that immediate measures (such as evacuation and sheltering) are not implemented within 24 hours and that people in the contaminated areas are moved 24 hours after exposure. In addition to this, to calculate group risk, the implementation of the legally required food measures were assumed.

Figure 8-3 shows that the group risk does not exceed the legal criterion under the Nuclear Facilities, Fissionable Materials and Ores Decree ('the Decree') for permissible group risk for any of the victims; instead it remains below the criterion by at least a factor of 10 (Table 8-4).

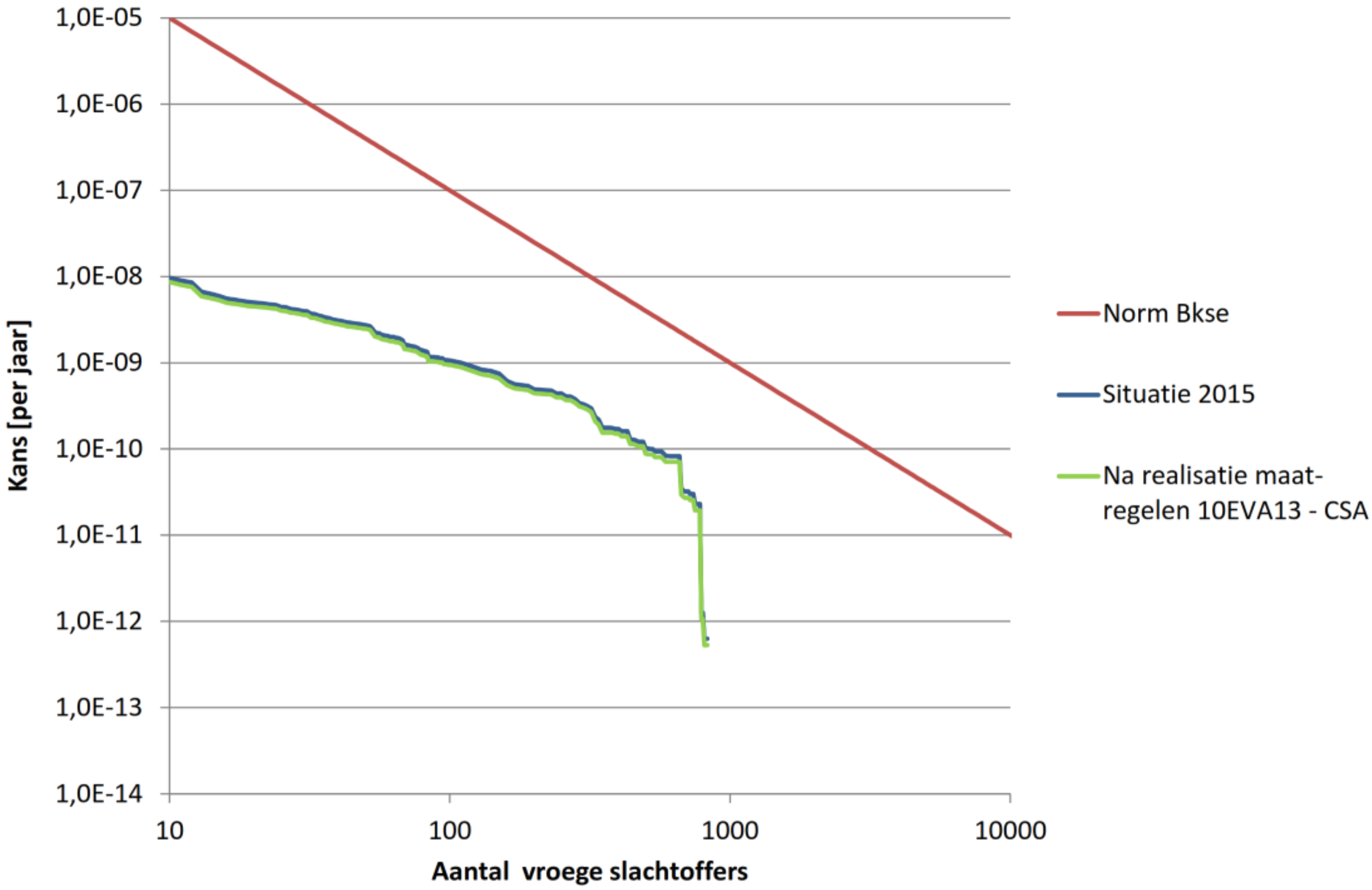


Figure 8-3 Group risk due to the Borssele nuclear power plant (EPZ, 2015)

Figure 8-3 also gives the results for the situation in 2015 and thereafter, after implementing safety-enhancing measures based on the 10-yearly evaluation over the period from 2003 to 2012 (10EVA13) and the stress test (CSA). As stated previously, both situations are sufficiently representative of the current situation.

For more details, please refer to the Safety Report (EPZ, 2015), accompanying the Borssele nuclear power plant's current permit under the Nuclear Energy Act, which describes the postulated events and the response from the plant (in other words, the course of the accident) and demonstrates that safety is ensured within the legal criteria. The Safety Report is the appropriate place for describing the postulated initiating events with their associated assumptions and preconditions, the plant response (in other words, the course of the accident) and the evidence that safety is ensured.

8.4.1.3 Transboundary effects

It has to be determined whether there are potential significant adverse effects on the environment in another country as a result of a proposed activity. If this is the case, the requirements of the Dutch Environmental and Planning Act [*Omgevingswet*] (Article 16.42b) and the Dutch Environmental and Planning Decree [*Omgevingsbesluit*] (Article 11.22-11.26) have to be implemented. For the proposed activity, the extent to which the effects that occur for the nuclear safety aspect take place beyond the Netherlands' borders has therefore been assessed. The closest countries are Belgium, England and Germany which are at least about 16, 157 and 156 km, respectively, from the Borssele nuclear power plant to the national border. These effects are assessed per aspect.

Assessment of the radiological requirements in postulated design basis accidents

As concluded in Section 8.4.1.1 the maximum radiation exposure due to postulated events more than meets the assessment criteria for this purpose (Table 8-3). The maximum level is in the immediate vicinity of the Borssele nuclear power plant. The radiation dose lessens as the distance increases. As a result, the Borssele nuclear power plant has no significant impact on Belgian territory in relation to the assessment criteria in the Netherlands, and therefore this also applies to the countries further away from the Netherlands. Although it is highly unlikely, an accident may happen that may affect Belgian territory.

Permissible risk as a consequence of accidents

The impact assessment of permissible risk due to accidents for local residents concluded that both the individual risk and the group risk more than meet the applicable assessment criteria (Table 8-4). Again, the maximum level is in the immediate vicinity of the Borssele nuclear power plant and as the distance increases, the site-specific risk will continue to decrease. Due to its distance from the Belgian border, the risk is therefore very low when compared to the Dutch assessment criteria and therefore also for countries bordering the Netherlands that are further away from KCB.

Based on the above, the conclusion is that there will be no potential significant adverse environmental effects in another country and that, from a nuclear safety perspective, the likelihood of transboundary effects is highly unlikely based on the Dutch assessment criteria.

8.4.2 Ageing management

All plants are affected by deterioration. To safeguard nuclear safety, the effects of the ageing of the systems, components and structures that play a role in nuclear safety must be controlled during all phases of their service life. This section describes how EPZ implements ageing management.

Ageing management involves three different kinds of deterioration, namely conceptual, technical and physical ageing. These different forms are described, together with how EPZ interprets them. The current permit is subject to several permit requirements in the context of ageing management (ANVS, 4 dec 2018; ANVS-2018/20254).

8.4.2.1 Conceptual ageing

Conceptual ageing occurs when, for example, the thinking on safety for nuclear power changes or when the state of the art is improved. The pursuit of continuous improvement in safety requires the regular evaluation of new developments in the field and their applicability to the plant. Managing this kind of obsolescence is covered by 10-yearly safety evaluations (10EVA) at the Borssele nuclear power plant. Permit requirement C.19 lays down that EPZ has to conduct a 10-yearly safety evaluation over the period from 2013 to 2022. To this end, EPZ submitted in advance a final plan of action and an assessment framework to ANVS for approval. This ensures that ANVS can check in advance whether the 10-yearly safety evaluation is carried out in accordance with applicable legislation and regulations (ANVS, 4 dec 2018; ANVS-2018/20254).

A 10-yearly safety evaluation (10EVA) includes a review of current regulations in the Netherlands and an evaluation of the state of the art to further enhance nuclear safety. The Regulation on Safety of Nuclear Facilities stipulates that a safety evaluation must take place at least once every ten years, which involves assessing whether the design basis requirements are met and new safety improvements can be identified. One of the components of this safety evaluation is the ageing of the nuclear reactor (Article 11.4.b of the Regulation on Safety of Nuclear Facilities (Nederlandse Overheid, 6 juni 2017)). International developments in the field of nuclear safety and radiation protection are included in this safety evaluation. The 10EVA method, in accordance with the IAEA policy guideline SSG-25 *Safety Review of Nuclear Power Plants* (IAEA, 2013) and the ANVS guidelines for 10-yearly evaluations of nuclear plants (ANVS, 2021), consists of the following steps:

- 10EVA evaluation phase
  - The basic document, setting out all 15 areas of focus, i.e. safety factors, describes how they are evaluated. This document is submitted to the ANVS for approval. Ageing management is one of these areas of focus.
  - During the evaluation of these safety factors, areas for improvement were identified, presenting potential for improvement in nuclear safety and/or radiation protection. These areas for improvement are reported in fifteen safety factor progress reports submitted to the ANVS for approval.
  - The areas for improvement of all safety factors are clustered and ranked according to the importance of safety.

- Improvement measures are defined so that the findings of the evaluation are implemented.
- 10EVA implementation phase
  - Drafting a conceptual improvement plan
  - Once the competent authority has given its approval, the improvement measures are implemented in accordance with the conceptual plan for improvement.

The last fully completed 10-yearly safety evaluation (including improvement measures) is the 10EVA13. In addition to improvement measures ensuing from the normal 10EVA process, improvement measures were also identified based on studies carried out as part of the 10EVA13 project following the complementary safety analysis ('stress test') conducted following the Fukushima accident. These improvement measures have since been implemented. Of the 10-yearly safety evaluation (for the period from 2013 to 2022), the evaluation phase, as per permit requirement C.19, was completed in 2023. The measures have to be implemented by the end of 2027.

The modifications made to the Borssele nuclear power plant and the organisation over the past decades, based on these periodic safety evaluations, can be divided into several main themes. The guiding principles include the expansion of emergency power supplies, system modifications and the expansion of core cooling capabilities. The organisation was also made more resilient by expanding its scope, knowledge and skills. Below are some examples of the modifications that have been made over recent decades (EPZ, 20-07-2015):

- Improving the power supply:
  - Additional emergency diesel generators.
  - Additional connection to the external power grid for the KCB's own power supply.
- Expansion of safety systems:
  - Bunkered additional water injection systems for cooling the reactor.
  - Additional accident instrumentation for process information during accidents.
  - Emergency water system with groundwater wells.
  - Spatial separation of safety systems to enhance independence.
  - Increased autarky time through automatically operating safety systems and having sufficient diesel and water supplies.
  - Increasing resilience to external events such as flooding, earthquakes, kerosene fires and an explosive gas cloud from the Western Scheldt.
  - Filtered overpressure protection of the containment during accidents.
  - Passive hydrogen recombiners to prevent explosions during accidents.
- Improving the organisation and human factors:
  - Extending the emergency procedures.
  - Obligatory training courses using the simulator.
  - Using probabilistic analyses.

With all the physical and organisational measures in place, the probability of a nuclear event that affects humans and the environment has been reduced by about 1,000 times over the past 40 years, as shown in the figure below. This figure gives the change in the probability of a core melt accident over time, known as the 'core melt frequency'. The core melt frequency is an oft-used indicator to demonstrate that nuclear safety objectives have been met (IAEA, 2010). The core melt frequency is a measure of the probability of damaging the nuclear fuel in the reactor after the occurrence of an initiating event (NRC, 2023).

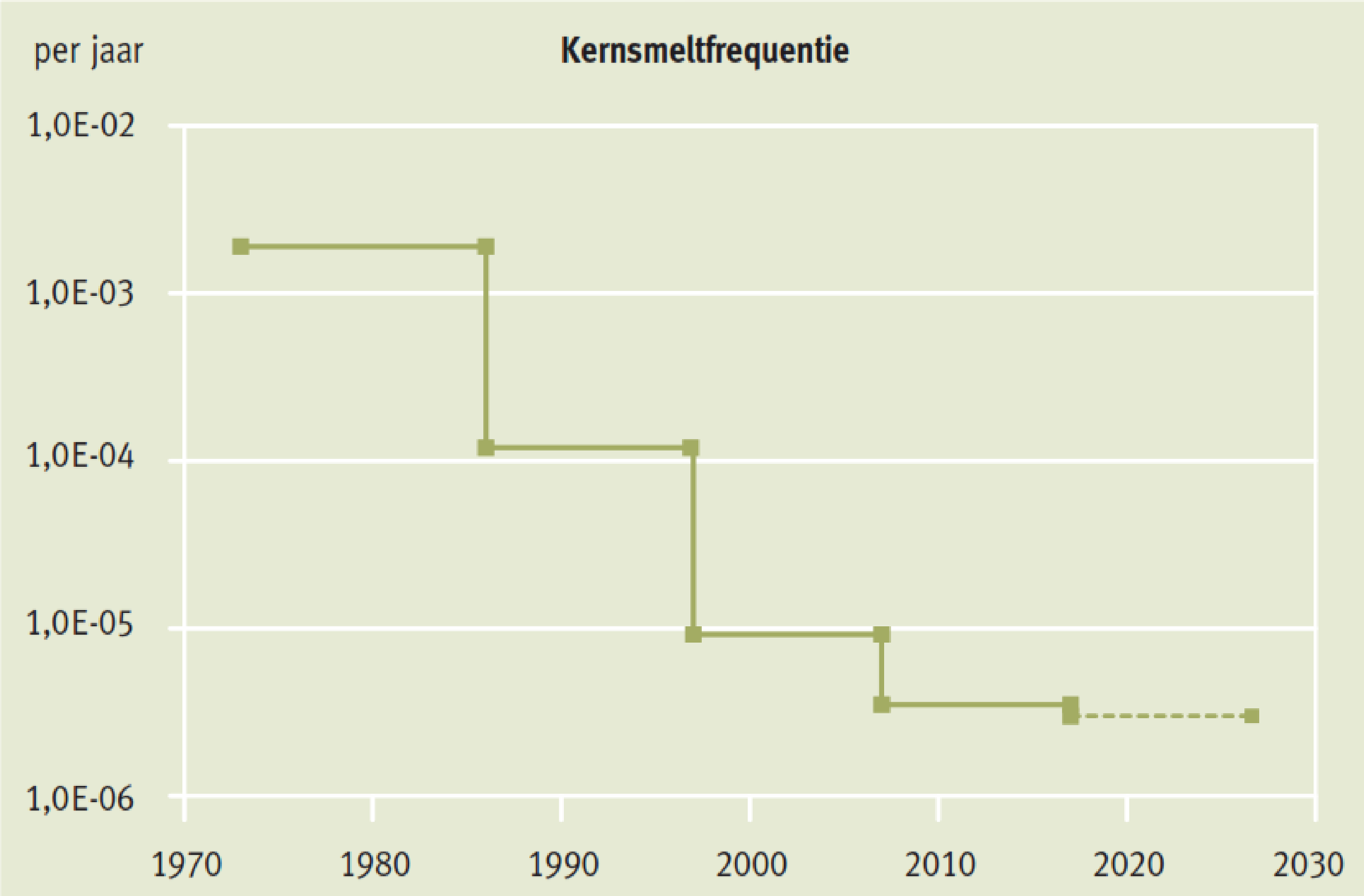


Figure 8-4 Trends in core melt frequency[41] (EPZ, 20-07-2015)

8.4.2.2 Technical ageing

The second type of ageing is technical ageing,which is usually called obsolescence.Examples of obsolescence are when the knowledge and skills within or beyond the organisation are no longer sufficient to maintain the relevant systems or parts can no longer be supplied. In other words, components are not available because they are no longer produced or supported by the manufacturer. Analogue operating systems are a specific example of this.

At EPZ, this kind of obsolescence is consigned to maintenance operations, which includes managing spare parts. Spare parts have been kept in stock for critical plant parts since 1973. Essential components of safety devices, pumps and control systems are managed in a controlled manner. Based on this, the organisation knows what is in stock as well as the condition of spare parts. If a certain part is no longer available at the supplier, another supplier is sought. If the replacements are not identical, the procedure for replacing parts as set out in permit requirement A.1 is followed (ANVS, 4 dec 2018; ANVS-2018/20254). As part of this change procedure, any changes that may potentially affect nuclear safety are assessed by a competent specialist and the internal and external reactor safety committee.

To maintain and enhance the knowledge and skills in the organisation, every employee is trained according to the qualification requirements associated with his/her position; this is repeated periodically. These qualifying requirements depend on the position and the associated competencies. An important part of the periodic training for control room staff is the so-called 'simulator training'. Training takes place in the control room simulator. Control room staff are confronted with potential malfunctions and accidents in an accurately simulated main control room and backup control room using a computer model. This is how staff are trained to take the correct actions in the event that a similar situation were to actually happen. The control room simulator is currently being moved from its original location in Germany to the EPZ site, and will be available there going forward. These training sessions are not optional; if

[41] Whereby frequency = 1/probability. A frequency of 1 10^{-5} per year is the same as a probability of once in a hundred thousand years (1 10^{5}).

performance is unsatisfactory, the control room member of staff stands to lose his/her qualification for the job. This is in line with permit requirement B.6, which states that EPZ follows nuclear safety guideline 3.2.1: *Voorschriften Opleiding van Bedieningspersoneel van Kernenergiecentrales* [Rules for the Training of Operating Staff of NPPs] (ANVS, 4 dec 2018; ANVS-2018/20254).

To train staff in maintenance work, EPZ has a working practice simulator to hand. This simulator allows for the training of staff in the entire set of working practices, from work preparation to execution and debriefing. This improves the knowledge and skills needed for maintenance work.

In addition, various employees participate in national and international training courses, conferences and working groups. This expands the know-how available at EPZ with state-of-the-art knowledge.

8.4.2.3 Physical ageing

Materials deteriorate due to use and/or the passage of time. This is known as physical ageing, and it occurs in all elements, in so-called active as well as passive components. Active components are those that actively move to perform their function, such as pumps and valves. Examples of passive components include the casing of valves and pipelines. The physical ageing of passive components involves, for instance, the process material becoming brittle under the influence of irradiation, corrosion or fatigue due to, for instance, thermal transients that can compromise integrity and cause leakage. The physical ageing of active components manifests, for instance, when a valve no longer seals completely and is no longer leakproof or a pump fails to perform as well as it should (EPZ, 2015).

Physical ageing is controlled by doing maintenance on the plant in line with its design and according to applicable regulations. This applies to passive as well as active components. At the Borssele nuclear power plant, this is laid down in the EPZ maintenance programmes in accordance with NVR NS-G-2.6 *Maintenance, surveillance and in-service inspections in nuclear energy plants* (permit requirement B.6 (ANVS, 4 dec 2018; ANVS-2018/20254)). The extent and frequency of these programmes is determined depending on the importance to nuclear safety, inherent reliability, potential degradation mechanisms (based on operating experience, research and supplier recommendations), operating experience and the condition-monitoring results (permit requirement C.4 (ANVS, 4 dec 2018; ANVS-2018/20254)). The plant programmes are:

- Maintenance
  The maintenance programme includes safety-related parts on which preventive and/or condition-related maintenance is carried out. The depth, extent and frequency of servicing the components in question is determined based on nuclear regulations, supplier requirements, operating experience, the importance of safety, potential types of failure, the probability of failure and the condition of a component. EPZ uses a widely recognised, structured analysis method, the failure mode and effects analysis (FMEA) when determining these factors. In addition, probabilistic safety evaluations (PSAs) are actively used. PSAs are used to determine effect of maintenance work on the core melt frequency (NRC, 2023). EPZ applies a strict operating limit to the increase of this frequency when planning preventive maintenance so that the consequences for safety are kept to a minimum (EPZ, sd).

- Surveillance (functional tests)
  EPZ carries out periodic functional tests of safety-related structures, systems and components (SSCs) in accordance with scenarios and procedures. ¿ These tests are carried out daily, weekly, annually or periodically over the years. The tests monitor whether the SSC in question can continue to fulfil its safety function without interruption based on specific acceptance criteria (permit requirement C.6 (ANVS, 4 dec 2018; ANVS-2018/20254)). If there are any anomalies, the system in question is calibrated, repaired or replaced. Examples of tests include inspecting temperature gauges, checking pump flow rates and periodically firing up the emergency diesel generators.

- In-service inspection (ISI)
  EPZ has an ISI programme that stipulates periodic non-destructive testing of the reactor vessel and other primary systems. The purpose of these investigations is to demonstrate that the required condition of the systems is maintained. The Pressure Equipment (Commodities Act) Decree [*Warenwetbesluit drukapparatuur*] (Nederlandse Overheid, 2020), i.e. the regulation on pressure equipment used in a nuclear setting (Nederlandse Overheid, 2018) and the American Society of Mechanical Engineers' Code for Operations and Maintenance of Nuclear Power Plants were used as additional guidelines when drafting the ISI programme. Non-destructive testing is carried out on the reactor vessel, welds, material transitions and connections of the primary system. Ultrasonic and X-ray technology is used to closely examine the components for imperfections as an indication of incipient cracking or reduction in

the wall thickness. The inspection intervals vary depending on the radiation dose, mechanical and thermal loads, but the entire system is inspected at least once every ten years. The ISI programme is periodically evaluated by EPZ and assessed by the inspection body designated by the ANVS, which acts as the supervisory authority (permit requirement C.7 (ANVS, 4 dec 2018; ANVS-2018/20254)).

EPZ has a specific ageing management process in place (permit requirement C.8 (ANVS, 4 dec 2018; ANVS-2018/20254)) in accordance with both NVR NS-G-2.12 as stipulated in the permit (permit requirement B.6 (ANVS, 4 dec 2018; ANVS-2018/20254)) as well as the current IAEA Guideline SSG-48 *Ageing management and development of a programme for the long-term operation of nuclear power plants* (IAEA, 2018). It is an integrated activity that involves assessing and recording physical ageing, and assessing whether the existing ageing management is adequate or needs to be adjusted. The integrated activity comprises two parts. The first part concerns maintenance tasks for all plant programmes. Internal information from operations and maintenance and external information, derived from research results, and being a member of the World Association of Nuclear Operators (WANO), the International Generic Ageing Lessons Learned (IGALL) and specific meetings and conferences held by the IAEA, for instance, are all used in the second part of the integrated activity.

In the process, tasks are laid down in procedures, whereby a plan-do-check-act cycle is applied (Deming's circle) as described in the SSG-48 (IAEA, 2018). This contributes to keeping knowledge and skills in ageing management up to date.

There are various ageing phenomena, including various forms of corrosion, wear and tear or thermal ageing. Several specific ageing phenomena are set out in EPZ's permit (ANVS, 4 dec 2018; ANVS-2018/20254) These phenomena are listed and an indication is given of how they are controlled:

- Reactor vessel embrittlement
  The reactor vessel at the Borssele nuclear power plant is a steel vessel with a thick wall. The reactor vessel is in the reactor core. Nuclear fission reactions occur in the reactor core, releasing energy and high-energy neutrons. The neutrons are largely delayed in the main coolant (water) and absorbed by the nuclear fuel and coolant in the reactor. However, some of the high-energy neutrons are not slowed down and/or absorbed, and end up on the inner wall of the reactor vessel. These high-energy neutrons can trigger microscopic changes in the material structure of the reactor wall, changing material properties in the process. The reactor wall becomes harder and more brittle, which means the wall becomes more susceptible to cracking. This effect is restricted to the reactor vessel wall level with the core and the internal components. This phenomenon is referred to as 'reactor vessel embrittlement'.

  An extensive testing programme has been running since the construction of the reactor. Its purpose is to predict the long-term behaviour as far as reactor vessel embrittlement is concerned. In the process, the extent of the neutron irradiation, on the one hand, is determined. A prognosis of the material behaviour is made based on this. On the other hand, the actual material behaviour is verified by testing specimens (of the same material as the reactor wall) exposed to neutron irradiation in the reactor. The results were taken into account in the renewed analyses carried out as part of the 2014 operating life extension, i.e. the LTO B project. The results demonstrate that the reactor vessel has generous safety margins as far as brittle break is concerned. These safety margins will continue to apply if the design operating life of the Borssele nuclear power plant is extended from forty to sixty years.

  Exposure from neutron irradiation is periodically evaluated against the assumptions used in the analysis (permit requirement C.46).

- System material fatigue
  The primary system, which includes the reactor vessel and the pipelines, is made of various kinds of steel. Stresses occur in the material due to mechanical and thermal loads. These loads come from variations in pressure and temperature, the components' own weight, and so on. The system is designed in such a way that the components are dimensioned so that the stresses that occur are well below the permissible standard stress of the material. This means that the stresses that occur will never lead to the failure of these components.

  Generally speaking, steel is very resistant to large static loads. The material has to come under a great deal of stress for a steel component to fail. If the loads vary over a long period of time, the system may collapse over time at lower stresses. Depending on the level of the fluctuating load, local microdamage may occur in the material. After several fluctuations in the load, for instance due to starting-up and shutting down the reactor, the microdamage may expand to become a (visible) crack in the material. Further load fluctuations may cause the crack to expand to a size that causes the affected component to fail. This phenomenon whereby a material is damaged due to varying loads is known as ‘fatigue’. The extent to which a material is subject to fatigue depends on the material type and on the extent and number of load fluctuations. Incidentally, fatigue is a slow process.

Renewed strength calculations were carried out during the LTO B project using KTA (Kerntechnischer Ausschuss) and ASME regulations. In the process, the fatigue factor was assessed using a range of postulated load fluctuations during normal operation as well as due to possible malfunctioning and/or accident scenarios.

A fatigue monitoring system (FAMOS) was installed in 2010 to monitor actual load fluctuations. This safeguards the principles and, with that, the validity, of the fatigue analyses. By monitoring actual fluctuations in the load, FAMOS gives better insight into how the actual load fluctuations relate to the load fluctuations in the design in fatigue analyses. Load fluctuations that occur are evaluated each year and the results are shared with the supervisory authority, ANVS (permit requirement C.48).

- Qualification of accident-resistant electrical equipment
  The Borssele nuclear power plant has electrical equipment to control and monitor the process. Special design requirements apply to some of this equipment, because it has to continue to function properly during and after a design basis accident under the environmental conditions prevailing at the time, such as increased temperature, pressure, relative humidity and higher radiation levels. This is the only way to have and maintain good and reliable insights into the state of the process or plant, and to assess the effectiveness of the control measures taken. This equipment is known as ‘accident-proof equipment’ and is qualified for the special design requirements. A limited technical lifespan is permitted for this equipment, provided it is replaced in good time. This kind of equipment is also relatively easy to replace.

  To monitor the qualified residual service life, measuring equipment has been fitted to monitor environmental conditions. With this information, periodically (every fuel cycle) the residual service life of the accident-resistant electrical components is determined based on a ‘database of residual service life’. Components for which a qualified residual service life of at least five years cannot be demonstrated require corrective measures in the form of requalification or replacement with qualified components (permit requirement C.49).

8.5 Extrapolation of the environmental situation

Extrapolating the environmental situation identifies where possible future (after 2033) problem areas may be an issue, and therefore where there may be gaps in knowledge which will have to be investigated further in Phase 2.

8.5.1 Emergencies and accident scenarios

As set out in Section 8.4.1, as it stands now the Borssele nuclear power plant meets the legal criteria in terms of controlling design basis accidents and their potential radiological consequences. It also meets the risk criteria for individual and group risks for beyond design basis accidents. The safety analyses underpinning this will have to be renewed for operations after 2033, based on the regulations and guidelines in force at the time. In the process, the transboundary effects will have to be considered once again.

As far as the emergencies and accident scenarios discussed in Section 8.4.1 are concerned, the following factors may affect the future environmental situation after 2033:
- Climate change.
- Construction of new nuclear power plants.
- Borssele Energy Hub.

8.5.2 Climate change

As far as climate change is concerned, there are several implications that may be relevant to nuclear safety at the Borssele nuclear power plant, namely:
- An increase in maximum seawater temperature, in connection with reactor cooling.
- An increase in maximum air temperature, in connection with the cooling of safety-related areas and systems.
- Rising sea levels, in connection with the risk of external flooding.
- An increase is extreme weather events, such as more severe storms posing an external threat.

Seawater and ambient air temperature
The increase in average temperature due to climate change will also trigger an increase in the maximum temperature of the water in the Western Scheldt. For the prevailing situation, it has been demonstrated that the cooling systems can perform adequately at the maximum possible water temperature, even if there is an accident. For a longer operating life after 2033, this will have to be demonstrated as part of the safety analyses of the maximum water temperature that may then occur. The results of the safety analyses will be included in EIA Phase 2. A similar situation applies to the ambient air temperature and its effect on air cooling in safety-related buildings.

Rising sea levels
Dykes protect the Borssele nuclear power plant from seawater flooding from the Western Scheldt. In addition, the plant itself is resistant to external flooding in the event that these dykes fail. As part of the 10-yearly safety evaluations and the stress test after the Fukushima accident, the margins of protection of the plant against flooding were increased further, taking into account the impact of a rise in sea levels. This demonstrates that KCB is adequately protected in the current situation. That said, for a longer operating life beyond 2033, this will have to be demonstrated for the maximum seawater levels postulated at that time. The results of this may be included in Phase 2 of the EIA. It should be noted that, based on the Royal Netherlands Meteorological Institute's *KNMI'23 climate scenarios* for 2050, the expected rise in sea levels for the North Sea coast is 16 to 38 cm compared to 2020. In the Western Scheldt, a water level rise of 20 to 30 cm is expected in the period up to 2050 for the 'high' scenario (Klimaateffectatlas, 2023). The permissible flood level of vital parts for nuclear safety at the Borssele nuclear power plant is 9.80 metres above the Amsterdam Ordnance Datum (NAP) (EPZ, sd). In comparison, the 1953 flood was caused by a water level of 4.55 metres above NAP. Therefore, given the wide margin between these two levels, a rise in sea levels is not expected to be a problem for nuclear safety.

Extreme weather events
Against a background of extreme weather events occurring due to climate change, the possible increase in maximum wind loads is particularly relevant, including the potential for hurricanes. The safety-related buildings at the Borssele nuclear power plant were designed with severe wind loads of up to 125 m/s in mind. This constitutes an ample buffer against potential storms at the site, including the effects of climate change. This demonstrates that KCB is adequately protected in the current situation. However, for a longer operating life beyond 2033, this will have to be demonstrated for the maximum wind speeds postulated at that time. The results of this may be included in Phase 2 of the EIA.

8.5.3 Construction of new nuclear power plants

When planning to build new nuclear power plants, it is up to those advocating for them to demonstrate that their impact on the Borssele nuclear power plant's nuclear safety will be sufficiently low. No problem areas are anticipated in terms of nuclear safety.

8.5.4 Borssele Energy Hub

Several developments are planned in the vicinity of the Borssele nuclear power plant as part of the Borssele Energy Hub (see Section 2.4). These developments include the expansion of the high-voltage substation in the Sloegebied and the connection of some wind energy projects on the North Sea.

In principle, these projects could affect accidents at the Borssele nuclear power plant and how they are controlled. However, it is up to these developments to demonstrate – as part of their permit procedures – that their impact in terms of external safety on the surrounding area is sufficiently low and complies with the relevant regulations. By doing so, there should be no direct impact on the nuclear safety situation.

8.5.5 Ageing management

The aim of ageing management, as discussed in Section 8.4.2 is to ensure that the Borssele nuclear power plant can be operated safely until 2034. An investigation is currently under way to assess whether the nuclear power plant can be operated safely after 2033. In particular, the technical operating life is determined by the expectation of how irreplaceable components, such as the reactor vessel, can remain in operation safely. Based on previous studies, these components are not showing evidence of problematic deterioration and therefore do not constitute an impediment to extending the operating life safely. Those components that can be replaced will have to be assessed to determine whether it is necessary or desirable to replace them. Before EPZ decides whether or not to operate the nuclear power plant after 2033, EPZ is going to conduct extensive technical studies to see if it can be done safely (EPZ, 23 juli 2020).

Before the Borssele nuclear power plant can continue operating after 2033, it will have to be demonstrated whether all safety-related systems, structures and components are in place and reliable for the anticipated operating period. This will be done under the auspices of ANVS as the supervisory authority and based on technical investigations, safety studies in accordance with the legislation, regulations and guidelines applicable at the time. Specifically, this means that the long-term operation (LTO) will be implemented for the anticipated operating period, following the development of LTO programmes for nuclear power plants as described in the relevant IAEA guidelines. Besides the technical aspects of obsolescence, this concerns the organisational, procedural and administrative aspects.

8.6 Outlook for EIA Phase 2

The technical investigation was completed during Phase 2 of the EIA, and the results must demonstrate that:

- The safety-related cooling systems are able to perform their cooling functions adequately, including in accident situations, so that nuclear safety is safeguarded at the maximum possible water temperature of the Western Scheldt water.
- The air cooling system in safety-related buildings is able to cool the air sufficiently, including in accident situations, at the maximum possible air temperature to safeguard nuclear safety.
- The Borssele nuclear power plant is sufficiently protected against the postulated maximum seawater levels to ensure nuclear safety.
- The Borssele nuclear power plant is sufficiently protected against the postulated maximum wind speeds to ensure nuclear safety.
- The effects of the ageing of the systems, components and structures that play a role in nuclear safety must be controlled during the intended operating life extension.
- Besides the technical aspects of obsolescence, the organisational, procedural and administrative aspects must be dealt with adequately in the LTO programme.

Based on these studies, it will be clear whether any physical adjustments to the nuclear power plant are necessary. This leads to the following environmental focal points for Phase 2 of the EIA:

- Updating the safety analyses for the purpose of reviewing the control of design basis accidents and their potential radiological consequences, as well as the risk criteria for individual and group risks for beyond design basis accidents.
- Updating the review of the transboundary impacts of accidents.

9 Water

9.1 Introduction

Only part of the heat released in the nuclear reactor is converted into electrical energy. The excess heat from the nuclear power plant has to be removed. At the Borssele nuclear power plant, this residual heat is released into water extracted from the Western Scheldt via a heat exchanger. Water from the Western Scheldt is then discharged back into the Western Scheldt at a slightly elevated temperature.

The fuel has to remain cooled and heat has to be released to the Western Scheldt even if the nuclear power plant is not operating. There are other cooling water systems for this purpose: the emergency and secondary cooling systems. Groundwater can be used for cooling in emergencies; that water also drains into the Western Scheldt. In the process of water cooling, the quality of the water taken in changes: agents are added to the emergency and secondary cooling systems to combat accretion in pipes, filters and pumps. During normal operations at the nuclear power plant, very small amounts of radioactive substances are released through the water. The discharge of conventional substances and heat and of radioactive substances is regulated based on permits under the Dutch Water Act [*Waterwet*], 2018 and the EPZ revision permit, 2016, respectively. Extracting groundwater is regulated by permits.

In this section, we describe the legal frameworks and criteria that apply for the assessment of the effects on the environmental aspect of water. In the process, we distinguish between effects on surface and groundwater. This chapter gives an overview of:

- The relevant policy frameworks for the environmental aspect of water.
- Current operations and the impact on the environment. These factors are compared with the policy frameworks and the standards and threshold values stated on the water permit.
- The transboundary implications of the current environmental situation at the nuclear power plant for water as an environmental aspect.
- The external factors that could influence the current operations at the Borssele nuclear power plant, such as climate change, and other changes in the direct vicinity and the environment further away.
- Knowledge gaps and environmental focal points for Phase 2.

9.2 Relevant policy frameworks

The relevant policy frameworks for the environmental aspect of water are described in this section. They are divided into international policies, national policies and water board policies. Table 9-1 gives an overview of the important legal and policy frameworks.

Table 9-1 Legal and policy frameworks for water

Policy, legislation and regulations	Contents and relevance
The OSPAR Convention	The purpose of the OSPAR Convention is to protect the marine environment of the north-eastern part of the Atlantic Ocean. The convention is important for the international coordination of the North Sea Policy. It is a platform on which North Sea countries coordinate their assessments of the marine environment, and the conclusions they draw from it, for the use of the North Sea. This avoids having diverse or even conflicting strategies for the sea (Rijksoverheid, 2024).
Water Framework Directive (European policy)	The aim of Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive) is to safeguard the water-dependent terrestrial natural environment from degradation, and to protect and improve aquatic ecosystems. To that end, Member States are obliged to draw up programmes of measures so that all surface waters and groundwater bodies are in so-called 'good condition'. In addition, protected areas have been designated under the Water Framework Directive. These areas are subject to additional quality standards. Protected areas include Natura 2000 sites, swimming areas, water that shellfish inhabit and water bodies where water is extracted for human consumption. The Water Framework Directive is elaborated in the Dutch Environmental and

Policy, legislation and regulations	Contents and relevance
	Planning Act [*Omgevingswet*] and the Dutch Living Environment (Quality) Decree [*Besluit kwaliteit leefomgeving*].
The 2022 Scheldt River Basin Management Plan (National policy)	The Water Framework Directive prescribes that river basin management plans must be drawn up, giving a description of the water systems, objectives, monitoring and conditions, measures and the economic impact of measures. River basin management plans are drawn up every six years for the Netherlands part of the four catchment areas: Rhine, Meuse, Scheldt and Ems. The river basin management plans have to meet European requirements. These plans are for use in the Netherlands. As is the case with the Water Framework Directive, the goals for the surface water are to ensure that it is in a good chemical and ecological condition. These conditions are determined solely by European environmental quality requirements laid down in the EU Directive on priority substances and biological species groups.
The Water Act (National policy) → replaced by the Environmental and Planning Act	The Dutch Water Act 2009 [*Waterwet*] principally regulates the management of water systems, including flood defences, surface water and groundwater bodies. The objective of the Act is to prevent or limit flooding, floods and water scarcity, to protect and improve the quality of water systems and to address the needs of society related to water systems. The Act is based on comprehensive management of the water system as a whole, including the integrated issuing of water permits for activities in, on, over or under water systems.
The Environment and Planning Act → the Dutch Living Environment (Activities) Decree (National policy)	Environmental regulations for companies are laid down in the Dutch Living Environment (Activities) Decree [*Besluit activiteiten leefomgeving*] in the set of regulations under the Dutch Environmental and Planning Act [*Omgevingswet*]. Government regulations are laid down in the decree for activities in the physical living environment, for instance, regulations concerning the natural environment, cultural heritage and airports. This decree replaced the Dutch Activities (Environmental Management) Decree [*Activiteitenbesluit*]. The Environment and Planning Act defines what constitutes an environmentally harmful activity and the decree states which environmentally harmful activities are subject to government regulations. In addition, the decree mentions whether those environmentally harmful activities require a notification or an environmental permit, and who the supervisory authority is.
The National Water Programme (National policy)	The Netherlands is a country that faces major water challenges and these challenges will only grow in the future because of other issues, such as climate change, subsidence, the lack of space and environmental pollution. The 2022-2027 National Water Programme (NWP) sets out the broad outlines, ambitions and implementation of national water policies and the management of national waters (and national waterways), namely water safety, water quality and climate adaptation. The key themes of the NWP are adapting to climate change, maintaining flood protection and the conservation of freshwater supplies. This is relevant for the effects on surface and groundwater. Important components of the NWP are the river basin management plans, the flood risk management plan and the North Sea Programme. Under the Water Framework Directive, river basin management plans are drawn up every six years for the parts of the river basin districts of the Rhine, Meuse, Scheldt and Ems that are part of the Netherlands.. Provinces, municipalities, water boards and the Directorate-General for Public Works and Water Management (Rijkswaterstaat) work together at each of the river basin districts to ensure that the surface and groundwater are chemically clean and ecologically healthy. As far as water policies are concerned, the NWP is an elaboration of the National Strategy on Spatial Planning and the Environment.
2022-2027 North Sea Programme (National policy)	The trend of the various developments concerning the North Sea is that its use is intensifying. At the same time, clear boundary conditions have been set nationally and internationally to restore and protect the North Sea ecosystem. This calls for an

Policy, legislation and regulations	Contents and relevance
	integration of management in general and water management in particular in the decades to come. The challenge in the foreseeable future is to find the right social balance to achieve efficient and safe spatial development of the North Sea that is in line with the preconditions for a healthy ecosystem. The government is using the 2022-2027 North Sea Programme to set the frameworks for the spatial use of the North Sea as it affects the state of the marine ecosystem as well as for policies aimed at improving its environmental condition. The North Sea Programme is an integral part of the 2022-2027 National Water Programme. The coherence in water policies on which the NWP relies also applies to the management and use of the North Sea. The specific implementation of this task is based on the continuation of existing policies, adapted and new policies, research and monitoring, and governance.
The Scheldestromen Water Board's bylaws and general rules (The water boards' and Rijkswaterstaat's policies)	A bylaw is a management regulation imposed by the water board. The water board lays down the rules in the bylaw for protecting and maintaining watercourses and flood defences. The Scheldestromen Water Board's water systems bylaw also lays down specific rules for groundwater extraction.
Rijkswaterstaat register (The water boards' and Rijkswaterstaat's policies)	A register is a (digital) map used for the management of waterways and flood defences. The Water Act regulates the registration obligation for all water management structures. The registers for the primary – major – flood defence systems were established in 2009 and updated in 2014. The register for public works on rivers comprises general maps that describe the location, type, dimensions and structures of public works.

9.3 Criteria

The abiotic effects on surface and groundwater have been studied in terms of water as an environmental aspect. Abiotic effects are those that are not biological, i.e. not derived from living organisms. The assessment criteria for this aspect are illustrated in Table 9-2.

Table 9-2 Assessment criteria

Aspects	Assessment criteria
Water quality	Impact on the chemical and thermic quality of the surface water.
Groundwater	The effects of groundwater extraction on the groundwater body and other users of groundwater; see also the 2014 Rijkswaterstaat permit.
Water quantity	The effect of extracting surface water.

During this phase of the EIA, a study is carried out to examine whether the environmental effects remain the same at current operating levels, or whether there is an increase or decrease compared to the current licensed space and the relevant policy frameworks.[42] The impact on the environment changes if:

- Operations produce a different volume of emission or dose on the receiving water system or subsystem in question.
- The characteristic condition of the receiving water system or subsystem in question changes (i.e. if the buffer capacity or background exposure of the system changes).

a. [42] This EIA will indicate whether the current permit needs to be revised if the impact on the environment changes.

- Standards and policy objectives change (i.e. if new substances are introduced, testing values are adjusted, testing methods change).

9.3.1 Water quality

Two aspects were considered for water quality: non-nuclear chemical water quality and thermal water system quality. The radiological quality of the water was also taken into account in the section on nuclear safety.

A properly functioning water system is necessary for both aspects of water quality. The criteria for a properly functioning water system are that water can be retained in locations where it is required and that sufficient supply and discharge capacity is available if there are water shortages or excess water. For an estuary like the Western Scheldt, this specifically means that management looks for a balance between the natural variation of the channels and the navigation requirements. The water board assesses the functioning of water system in systems where the water level is managed with weirs and pumping stations.

9.3.1.1 Non-radioactive chemical quality of the water

The parameters for chemical water quality in the Netherlands are taken from the Water Framework Directive. The standards differentiate between:

- Priority substances (the Dutch Water Quality Requirements and Monitoring Decree 2009 [Besluit kwaliteitseisen en monitoring water 2009]) (Rijksoverheid, 2009).
- Specific contaminating substances (directive on the monitoring of the Water Framework Directive) (Rijksoverheid, 2009).
- Standards for the assessment of emissions on surface water: The immission test establishes a relationship between a discharge and the water quality in the immediate vicinity (mixing zone) of the discharge.
- The European Bathing Water Directive sets out standards for bathing water for sites designated as waters in which people can swim.

9.3.1.2 Thermal water quality

Thermal discharge is assessed according to the assessment system for heat discharges of the CIW (Committee for Integrated Water Management) (Rijkswaterstaat, 2004) using three criteria: extraction, mixing zone and warming. Table 9-3 gives the criteria that apply to the various subsystems. Different requirements apply to rivers, the North Sea and estuaries. For rivers, the mixing zone is a zone where a higher temperature applies as the restriction than the temperature for estuaries and for the North Sea.

Table 9-3 Criteria for the assessment of thermal discharge (Rijkswaterstaat, 2004)

Subsystem	Parameter	Criterion
Immission criteria	(generic)	
	Warming	< 3°C compared to background temperature up to a maximum of 28°C
Rivers		
	Extraction	No significant effects on spawning areas and juvenile fish rearing areas, good fish passages, demonstrably minimise flow rate (optimise the flow rate)
	Mixing zone (T>30°C)	< 25% cross section
North Sea		
	Extraction	Endeavour to minimise extraction, not in spawning and juvenile fish rearing areas or migration routes, good fish passages
	Mixing zone (T>25°C)	The mixing zone must not reach the bottom

Subsystem	Parameter	Criterion
Estuaries		
	Extraction	Endeavour to minimise extraction, not in spawning and juvenile fish rearing areas or migration routes, good fish passages
	Mixing zone (T>25°C)	< 25% cross section

The warming is related to the background temperature at the edge of the water system or parts of it. The 25°C level applies to cyprinoids and shellfish waters.

The nuclear power plant draws cooling water from the Western Scheldt and discharges heated water into surface water after use at a plant. This affects the water temperature in the so-called ‘mixing zone’. The mixing zone is the area where the relatively warm water from a discharge source mixes with water from the surrounding area. The location of the mixing zone is relevant to the impact assessment, because the water temperature standards are weighted based on the extent of the mixing zone and the temperatures at the outer boundary of this mixing zone.

The water temperature of the Western Scheldt is taken as the background value when monitoring the influence of thermal water extraction and discharge on the extent of the mixing zone. The water temperature of the Western Scheldt fluctuates according to the season. Water temperatures show an upward trend. The permit includes conditions for limiting heat discharge if the lower limit of the water temperature in the Western Scheldt is exceeded. This lower limit is exceeded for a few days or hours a year, which has implications for operations. The impact on the thermal environment and on the mixing zone are examined in the description of current and future scenarios.

Xenobiotic substances are discharged when cooling water is discharged. These substances are required for operations, namely to prevent blockages in the pipe system and the filters. The extent of the discharge of xenobiotic substances into the Western Scheldt is described in this chapter. The substances discharged and whether the discharge leads to deterioration of surface water quality were examined for this purpose.

The quality of the water is compared to the objective and the current condition of the waters. Relevant for the discharge is whether there is deterioration in relation to the objectives and whether the discharge could be harmful to human and animal uses of the surface water, for instance, for bathing water and as a shellfish habitat. The biotic effects of water, and water quality in particular, were examined under the environmental aspect; see the section on ecology.

9.3.2 Groundwater

The nuclear power plant uses groundwater solely as an emergency supply for cooling if the emergency and secondary cooling systems are not available. Each month, the plant is tested and to this end saline groundwater is pumped from 40 metres below the surface.

Groundwater extraction is assessed based on the current condition and trends, and the current use of the groundwater body. An assessment is carried out to establish whether extraction may affect other users and the preservation of the good condition of the groundwater body.

The Environment and Planning Act regulates the management of groundwater based on a permit system. The extent of the extraction determines whether the water board or the province is the competent authority for the permit. The Province of Zeeland is the competent authority for major industrial extractions, i.e. more than 150,000 m^3 per year. Current extraction is around 15% below the limit. For this reason, the Scheldestromen Water Board is responsible for granting permits for groundwater extraction. In the 2019 Groundwater Memorandum, the water board explained which policies are relevant for the assessment of groundwater extraction. The water board’s interactive map of groundwater shows that the extraction[43] of the Borssele nuclear power plant is in the vicinity of three relevant protection areas. The description of the current situation for groundwater discusses this in greater detail.

[43] Registered in the National Groundwater Extraction Register under number 50679

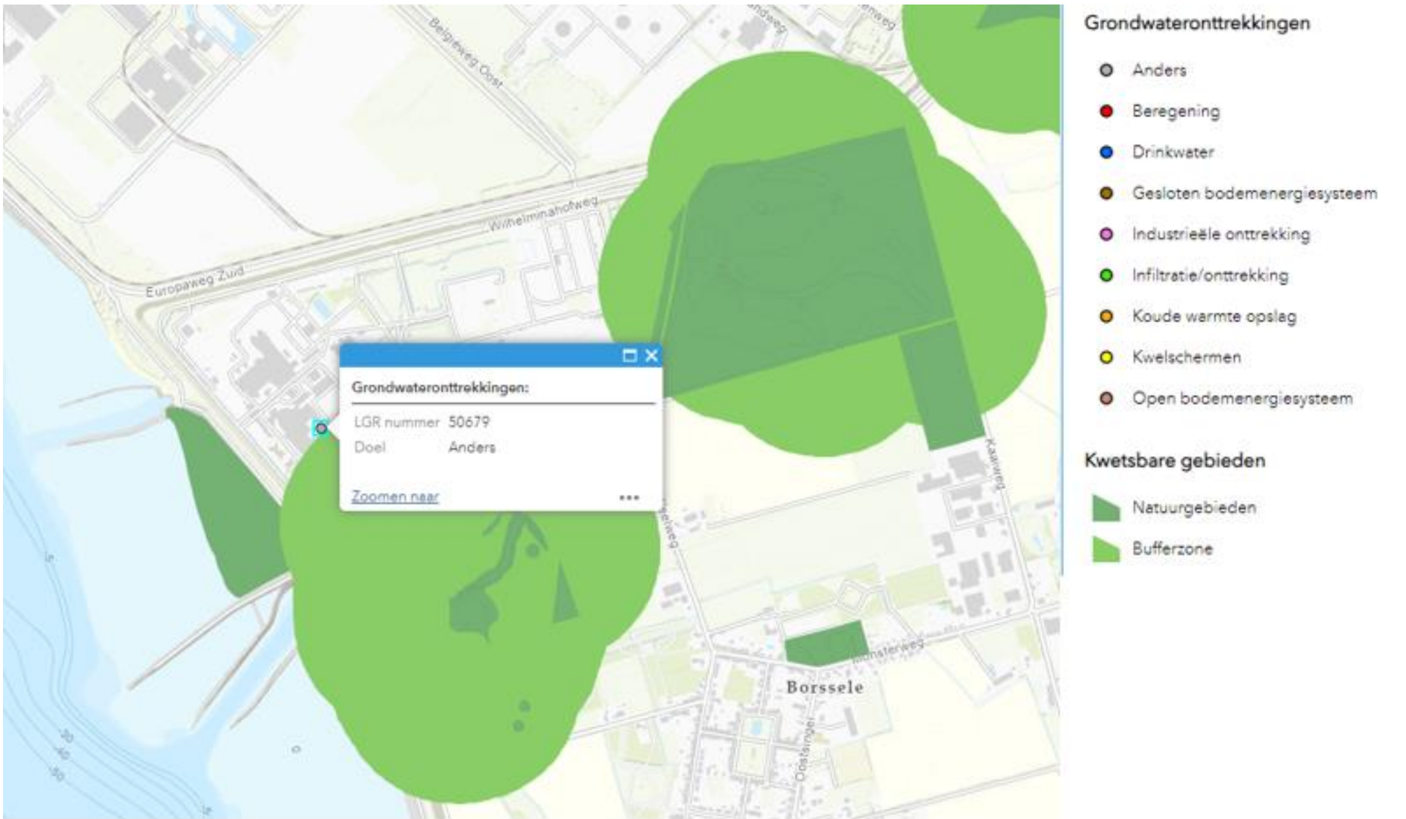


Figure 9-1 Groundwater management map for the Scheldestromen: vulnerable areas

9.3.3 Water quantity

The amount of surface water and the flow is important when assessing water consumption at the nuclear power plant and for the discharge of cooling water. This is also linked to the fact that the site is located on a polder. The criterion for the volume of surface water is the effect the extraction has on surface water.

The description takes into account the features of the Western Scheldt water system. The water quality criterion describes how features of the estuary are important for the assessment. The description of the water system describes the features of the Western Scheldt water system. The features of the mixing zone are determined by a combination of water volume properties (water taken in and the discharge flow rate) and the ratios of the volumes (heat and substances) discharged in relation to the concentrations in the receiving water.

9.4 Description of the current situation

This section discusses the water system and the current situation for each criterion. The current situation is defined as the situation during the period from 2017 to 2022.

9.4.1 Water system

The Borssele nuclear power plant is located on a polder that is part of a local water system: the site drains into a waterway from whence water is discharged into the Western Scheldt via weirs and a pumping station. The Western Scheldt water system is important for the extraction and discharge of cooling water.

Borssele polder

The Borssele nuclear power plant is located behind the sea dyke on a polder that is part of the Walcheren and Zuid-Beveland water system. The plot where the nuclear power plant is located is part of a drainage level section with a water level of about +0.15m on the Amsterdam Ordnance Datum (NAP). There is also a transformer substation at the same drainage level section. Water originating from seepage and rainwater runoff via the paved surface is drained to the south. Surface water flows via a weir and a culvert under the Weelhoekweg to the Borssele polder pumping station, which is located at the dyke to the south of the village of Borssele. The excess water in the polder is pumped out into the Western Scheldt.

The nuclear power plant site and the plant itself discharge various types of water into the surrounding area. The water permit (Rijkswaterstaat Zee en Delta, 2014) for the plant gives a list of the types of water flows. A distinction is made between water from the nuclear power plant (KCB) and the conventional power plant (CCB) that was decommissioned in 2015:

	Originating from	Discharged into
Cooling water	KCB	Western Scheldt
Industrial wastewater	KCB	Western Scheldt
Effluent	Neutralisation basin for the Borssele nuclear power plant and the wastewater treatment plant	Cooling water channel
Groundwater	KCB emergency cooling system	Western Scheldt
Cooling water (out of operation since 2015)	CCB	Western Scheldt
Industrial wastewater (out of operation since 2015)	CCB	Western Scheldt

Figure 9-2 Drainage of the Borssele nuclear power plant water level area to the Borssele surface water pumping station (Waterschap Scheldestromen, 2024)

Figure 9-3 Relevant locations of the Western Scheldt, Vlissingen, Sloegebied and Borssele water system

The Western Scheldt

The Borssele nuclear power plant is cooled with cooling water originating from the Western Scheldt. The cooling water inlet is connected to a short channel that is regularly kept at depth to prevent siltation of the inlet. The outlet for the heated cooling water into the Western Scheldt is 650 m north of the inlet. There is a nature reserve outside the dyke between the inlet and the outlet. This reserve is designated as a vulnerable area from the point of view of groundwater protection ('Nature reserves 2018' is indicated on Scheldestromen Water Board's interactive map of groundwater). There is a beach in a bathing area, the 'Borssele Bathing Beach', to the north of the outlet. The Ritthem Rammekens Bathing Beach is situated further to the west next to the entrance to the Sloegebied harbour. The water quality of the Western Scheldt is also affected by discharges from the adjacent Borssele polder pumping station, the two polder pumping stations that discharge into the harbours in the Sloegebied and by the combined outlet of the sewage treatment plant and the Zuidwatering polder pumping station.

The Scheldt is a cross-border river that passes through France, Belgium and the Netherlands. More than a third of the part of the Scheldt river basin in the Netherlands consists of water and includes the Province of Zeeland and small parts of the Provinces of North Brabant and South Holland. The catchment area includes the national waters of Eastern Scheldt and Western Scheldt and the coastal waters of the North Sea (Ministerie van Infrastructuur en Waterstaat, 2022).

The Western Scheldt is a branch of the sea in the South West Delta and the only open tidal estuary. The tidal volume of the Western Scheldt is the volume of water that is exchanged per tidal range (approximately six hours). At spring tide, the tidal volume with a tidal range of about 4 metres at Borssele is much larger than at neap tide (approx. 2 m tidal range). Tidal volume is estimated to average between 1 and 2.2 billion m^3 per range (National Waters 2005 potential cooling capacity). The tidal flow during neap tide is assumed to be around 0.3 billion m^3. The lowest flow rate produces the biggest mixing zone (hardly any high-speed flow). The time when the tide is at its lowest during spring tide also produces a large mixing zone with a relatively deep reach in the tidal channel over a period of about one hour.

The tidal flow is estimated to be in the region of 50,000 m³/s on average. At neap tide, the tidal flow is in the order of 15,000 m³/s. (Estimates based on Arcadis' expert judgement.)

The water consumption at the power station is restricted: the discharge under the permit is 23.2 m³/s for cooling water and 15.1 m³/s for processing water. The total discharge under the permit is 38.3 m³/s. That amounts to 0.28% of the estimated minimum tidal flow during neap tide.

The extent of the mixing zone and the features of the tidal zone are more precisely depicted in a model calculation of the tidal system and discharge. To the best of our knowledge, this model calculation has not been made. We recommend carrying out the calculation to clarify the extent of the mixing zone and its dynamics during different tidal phases.

The Western Scheldt waterway is valuable from an economic perspective because of the ports of Zeeland, Ghent and Antwerp. The ports play an important role in the shaping of the Scheldt. Hydrological interventions have been carried out in the Western Scheldt. For instance, when deepening the Western Scheldt navigation channels, the sills are removed so that ships with greater draught can reach the Port of Antwerp. Other hydrological interventions include dredging, bank protection, the building of dykes and supplying water. These hydrological interventions affect the ecological functioning of the area. The Western Scheldt waterway [NL89_WESTSDE_OWL] has been designated as 'significantly altered' (Rijkswaterstaat, 2009). If waterways have changed significantly, a different layout of the water system may render this natural reference unattainable. The status of the general physical chemistry is moderate to good (Ministerie van Infrastructuur en Waterstaat, 2023). The levels of dissolved inorganic nitrogen (DIN) in winter months exceed the standard. The other indicators (maximum levels of water temperature and summer-average oxygen saturation levels) are good.

Table 9-4 State of the general physical chemistry of the Western Scheldt (Ministerie van Infrastructuur en Waterstaat, 2023)

Indicator	Situation in 2023
Total phosphorus (summer average) (mg P/l)	N/A
Total nitrogen (summer average) (mg P/l)	N/A
DIN (winter period) (mg N/l), ≤ 1.25	Moderate
Salinity (summer average) (mg Cl/l)	N/A
Temperature (max. level) (≤ 25°C)	Good
Acidity (summer average) (-)	N/A
Oxygen saturation level (summer average) (%)	Good
Transparency (summer average) (m)	N/A

In addition, the water manager (Rijkswaterstaat) measures and tests the chemical water quality of the Western Scheldt. The chemical condition of the surface water **did not meet the standards** in 2023. This applies to ubiquitous substances and specific contaminants. Ubiquitous substances are substances that are no longer permitted but were previously used widely and have hardly degraded (high persistence). These are commonly occurring substances in the water environment. Table 9-5 gives the specific contaminants, ubiquitous substances and non- ubiquitous substances that exceed the standard. There is background exposure for ammonium because it arises from seepage into the area (Ministerie van Infrastructuur en Waterstaat, 2023).

Table 9-5 Specific contaminants, ubiquitous substances and non-ubiquitous substances that exceed the standard (Ministerie van Infrastructuur en Waterstaat, 2023; Overheid.nl, 2024)

Substance
Specific contaminants
arsenic
benzo[a]anthracene
chrysene

Substance
imidacloprid
cobalt
zinc
Non-ubiquitous substances
None
Ubiquitous substances
benzo[a]pyrene
benzo[b]fluoranthene
benzo[ghi]perylene
benzo[k]fluoranthene
mercury
Per- and polyfluoroalkyl substances (PFAS)
the sum of PBDE28, 47, 99, 100, 153, 154
tributyltin (cation)

The substances listed in the nuclear power plant discharge permit (Table 9-8) are not listed on the Water Framework Directive fact sheet for the Western Scheldt, with the only exception of heat discharge (temperature).

Supply to and removal from the nuclear power plant

Cleaning and dredging work is carried out as part of the management of the inlet and outlet channels of the nuclear power plant. Dredge spoil is removed from the cooling water intake channel of the nuclear power plant and deposited/dispersed in designated sections in the Western Scheldt in accordance with the water permit. The nuclear power plant has a permit to deposit 90,000 m^3 dredge spoil annually. For more information, see the chapter on ecology.

9.4.2 Water quality

The water quality of the Western Scheldt is affected because the nuclear power plant discharges heat through the water. Substances are also discharged. Non-radioactive substances are discussed in this chapter. See Section 7 and 8 for more information about radioactive substances. The assessment of the water quality in the Western Scheldt reveals that temperature and heat discharge are the most relevant parameters to address. There are generic water quality policies for the other substances.

Thermal water quality

The water temperature in the Western Scheldt is systematically measured at Vlissingen, Terneuzen and four other locations further upstream. The water temperature in Vlissingen fluctuates between approximately 4°C and 22.5°C each year. The measurements are showing evidence of a trend (increase) of 0.06°C per year.

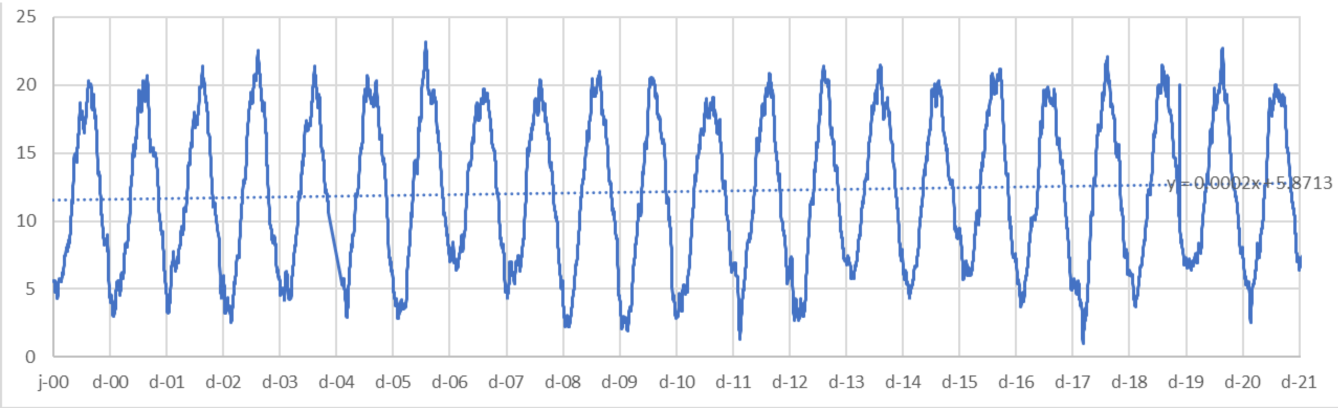


Figure 9-4 Water temperature at the Western Scheldt at Vlissingen (2000 to 2022) (Rijkswaterstaat, 2024)

Table 9-6 below shows that the Western Scheldt is on average slightly warmer than the North Sea at the Goeree Light Platform. The Western Scheldt is about 0.5°C warmer upstream (at Bath) than it is at Vlissingen based on the 10-year trend. All waters show evidence of an increase in water temperature in the order of 0.05°C per year over the past 23 years. The water temperature on the Western Scheldt still meets the surface water temperature target (<25 ° C) for the Netherlands and under the Water Framework Directive.

Table 9-6 Water temperature (°C) in the Western Scheldt and on the of North Sea (Goeree Light Platform): measured levels and expectations based on the calculated trend.

Location	Beginning	End	Ave T	T2023	Trend (C/10 yr)	T2030	T2050
Goeree Light Platform	1-1-1990	31-12-2022	12.0	12.8	0.5	13.2	14.4
Vlissingen	1-1-2000	31-12-2022	12.2	12.9	0.6	13.3	14.4
Bath	12-4-2000	12-4-2000	13.3	13.4	0.1	13.5	13.6

Three criteria are taken into account in the assessment system for heat discharges (Rijkswaterstaat, 2004), namely extraction, the mixing zone and warming.

- Extraction: Minimise extraction, not in spawning and juvenile fish rearing areas or migration routes, good fish passages.
- Mixing zone: The mixing zone of the heat discharge is the area where the temperature is below 25°C. The criterion for estuaries such as the Western Scheldt is that the size of the mixing zone must be smaller than 25% of the cross-sectional area.
- Warming: For warming, the generic immission requirement is that it must remain less than 3°C compared to the background temperature, up to a maximum of 25°C (the limit for shellfish waters). Table 9-4 about the Western Scheldt shows that occasionally the temperature rises above 22°C.

When seawater temperatures exceed 22°C, the Borssele nuclear power plant takes into account the maximum temperature in its production: the immission requirement to keep warming below 25 degrees is met by temporarily producing less energy.

The conditioned water is pumped around in a closed circuit in the nuclear power plant's primary system (EPZ, 2021). In addition, water from the Western Scheldt is used as cooling water; this water is not part of the primary system. The cooling water used is discharged back into the Western Scheldt. The discharge is done via a cooling water outlet about 600 m north-west of the Noordnol (Gedeputeerde Staten van Zeeland, 1984). Table 9-7 gives an overview of the heat emission into the Western Scheldt. The heat of the discharged water must be no more than 980 MW (1 MW = 1 MJ/s) and the flow rate must be no more than 23.2 m^3/s. The maximum heat discharged through water was not exceeded in the period from 2017 to 2022 (EPZ, 2017-2022). Heat emissions in 2022 reached about 82% of the amount stipulated in the permit; emissions were lower during the other years.

Table 9-7 Water emission from the Borssele nuclear power plant into the Western Scheldt (EPZ, 2017-2022)

Year	2017	2018	2019	2020	2021	2022	Average	Max.	Max./permit	Under the permit
Heat discharge (MJ/s)	658	681	760	798	744	807	741	807	82%	980

Chemical water quality: non-radioactive discharge

Discharge processing aids: Conventional substances discharged as processing aids into the Western Scheldt from the Borssele nuclear power plant are given in Table 9-8. The standards/threshold values under the permit were not exceeded from 2017 to 2022.

Table 9-8 Discharge of processing aids (EPZ, 2017-2022)

Substance	Discharge (kg/year)						Standard/threshold value	Discharge method and volume
	2017	**2018**	**2019**	**2020**	**2021**	**2022**		
Caustic soda	21,254	20,158	25,061	19,711	3,228	3,343		Dissolved in water – Neutralised
Hydrochloric acid	23,839	22,084	20,983	22,638	2,199	2,144		Dissolved in water – Neutralised
Iron sulphate	16,000	15,000	14,000	14,000	15,000	13,000	46,000 kg/year	Total volume of iron sulphate used discharged into the Western Scheldt
Total chlorine	3,562	3,695	4,730	4,730	3,672	3,679	0.5 g/l (at 4,200 m^3/h)	Partially discharged into the Western Scheldt through the degradation of sodium hypochlorite
Nalco TRAC 110	144	206	147	184	105	37	Article 16, revision of the permit 2014	50% from water
Hydrazine	1.5	1	0.8	0.49	1	0.75	Article 16, revision of the permit 2014	Partially discharged into the Western Scheldt because the rest is processed as hazardous waste
Ammonia	738	556	765	811	715	741	Article 16, revision of the permit 2014	

Substance	Discharge (kg/year)						Standard/threshold value	Discharge method and volume
Boric acid	44.1 (conc.: <50mg/l)	31 (conc.: <50mg/l)	24 (conc.: <50mg/l)	18.3 (conc.: <50mg/l)	31 (conc.: <50mg/l)	29 (conc.: <50mg/l)	250 (concentration requirement: 50 mg/l in a maximum flow rate of 40m³/hour)	

Eutrophying and oxygen-consuming substances: The contamination due to oxygen-consuming substances is expressed in VeO (VeO – pollution unit of oxygen-binding substances). Rijkswaterstaat has set a limit for this, namely 65 VeO and 10 VeO respectively (total of 75 VeO). Throughout the year, pollution units related to oxygen consumption (VeO) are discharged through the building drainage system. Table 9-9 gives an overview of the VeO discharged per year from 2017 to 2021. The VeO was above the set norm of 65 VeO in 2021, but below the total VeO of 75 VeO. The maximum VeO was not exceeded during the other years in this period (EPZ, 2017-2022).

Table 9-9 Eutrophying and oxygen-consuming substances (EPZ, 2017-2022)

Year	2017	2018	2019	2020	2021	2022	Average	Maximum
Pollution units (VeO)	50.4	40.1	59.3	54.1	70	52	54.3	70

Dispersion of dredge spoil: A maximum volume of dredge spoil has also been agreed: 90,000 m^3 per year. Dredge spoil is released when the nuclear power plant's cooling water inlet channel is dredged Table 9-10 gives an overview of the dredge spoil dispersed each year during this period (EPZ, 2017-2022). The average and maximum annual volumes are below the agreed maximum volume.

Table 9-10 Dispersion of dredge spoil per year (EPZ, 2017-2022)

Year	2017	2018	2019	2020	2021	2022	Average	Maximum
Dredge spoil (m^3)	24,000	52,000	17,000	46,000	53,000	32,000	37,000	53,000

Dredging moves substances in the Western Scheldt that had previously settled on the bottom. Some of these substances are historical contaminants that fall under the category of ubiquitous substances, which are responsible for exceeding the standard for the Western Scheldt. See Section 6.3.3.2 for more information about dredging.

9.4.3 Groundwater

Legislation: the current groundwater extraction is registered in the national register of groundwater extractions and infiltrations under number 50679. Scheldestromen Water Board's interactive map of groundwater shows that the extraction is close to three areas that have protected status; they are protected areas that are part of the Netherlands Nature Network (NNN), namely:

- The nature conservation area between the inlet and the outlet.
- The buffer zone of the nature conservation area and the NNN area immediately south of the Borssele nuclear power plant.
- The buffer zone of the nature conservation area and the NNN area east of the converter station.

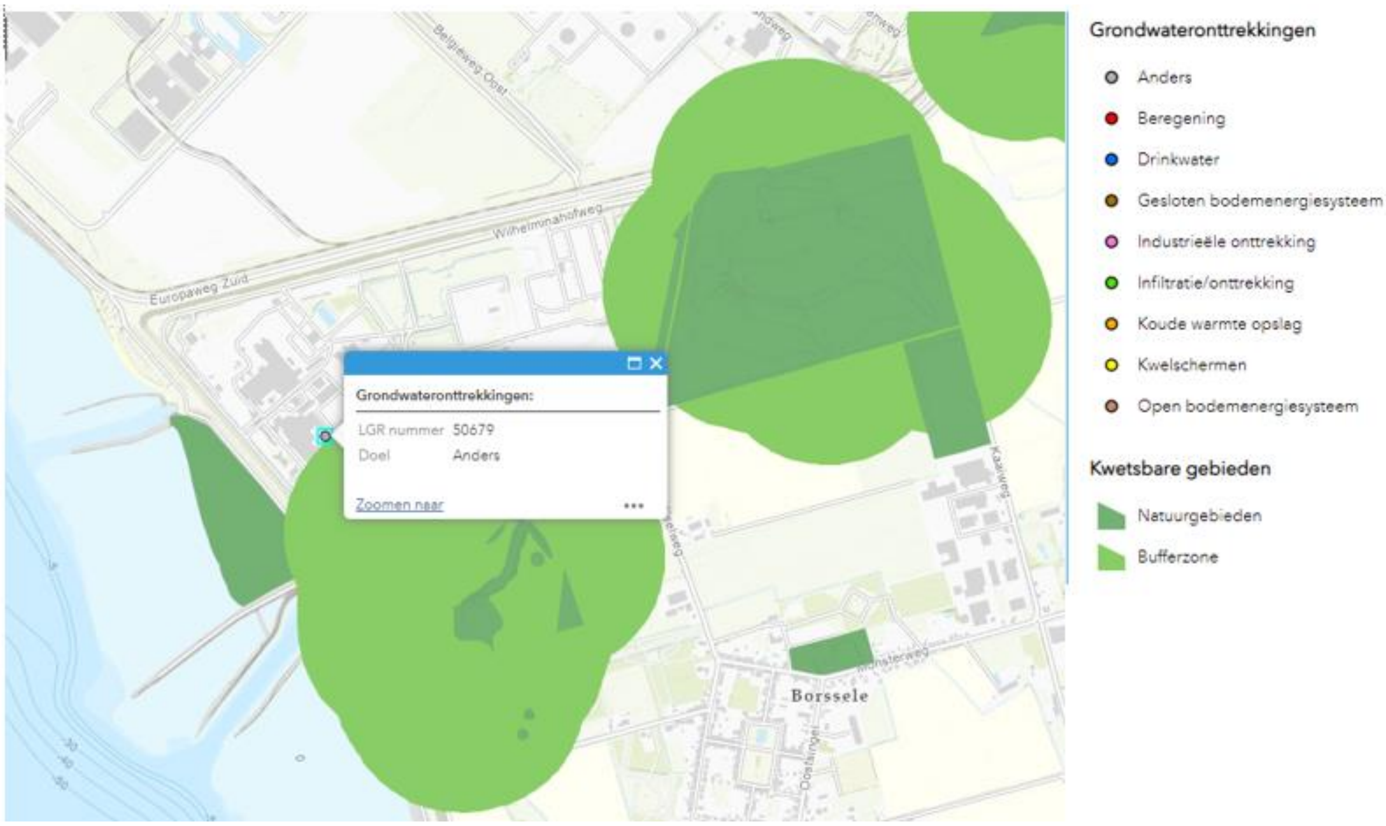


Figure 9-5 Location of the Borssele nuclear power plant's groundwater extraction in relation to protected areas (groundwater map, (Waterschap Scheldestromen, 2024)

Saline groundwater pumped up: An emergency cooling water backup system has been installed at the nuclear power plant to address the situation if water from the Western Scheldt is not available. This system uses eight boreholes that reach the (saline) groundwater. Each available borehole can produce a flow rate of around 39.6 m^3/h indefinitely. The limit under the permit is 18,000 m^3 per year. The groundwater is discharged into the Western Scheldt after use. The volume of saline groundwater pumped up during the period from 2017 to 2022 did not exceed the volume allowed under the permit (EPZ, 2017-2022).

Table 9-11 Saline groundwater pumped up for maintaining the emergency cooling water backup system (EPZ, 2017-2022)

Year	Saline groundwater pumped up (m^3)	% compared to the volume permitted under the permit	Chloride concentration (mg/l)
2017	3,273	18	16,600 – 18,620
2018	1,287	7	18,880
2019	1,565	5.2	18,170
2020	1,258	4.2	16,581
2021	2,373	13.2	18,880
2022	1,179	6.6	19,070

The volumes of salt water pumped up are discharged into the Western Scheldt. The maximum permitted flow rate (18,000 m^3 per year) equates to 0.6 litres per second. This flow rate is negligible compared to the average tidal flow rate.

Groundwater contamination: Due to operational incidents, the groundwater has been contaminated twice with an agent to prevent corrosion (rust damage). The contaminants were investigated and cleaned up during a decontamination process. Every year, several monitoring wells are sampled to check whether contamination has occurred and whether further action is needed.

Tritium measurements: Measurements for the detection of the radioactive substance tritium (3H) are carried out in the groundwater at several locations under the Borssele nuclear power plant. No tritium was detected above the detection limit in the period from 2017 to 2022 (EPZ, 2017-2022). The criterion for the detection limit in liquid discharges of tritium is 1^{E}+05 Bq/m3 (List A.2 from the ANVS' Regulation on Basic Safety Standards for Radiation Protection).

9.4.4 Transboundary effects

The conclusion as far as the cooling water discharge from the nuclear power plant is concerned is that there may be (limited) transboundary effects during normal operations for the environmental aspect of water. The temperature of this plant may increase by less than 1°C at the Dutch border, about 3.4 km away from the discharge point. The border with Belgium from the Borssele site is about 47 km upstream along the Western Scheldt. In the direction of the North Sea, the shortest distance to the Belgian part of the North Sea is about 25 km.

The discharge plume and heat plume may have an effect up to certain distance from the nuclear power plant. The reach of the plumes is limited. The extent of the heat and discharge plumes have not been determined, nor have they been clarified. The reason for this is that no model studies have been conducted. The plume is expected to be an order of magnitude smaller (0.25 to 5 km) than the distances to the borders with neighbouring Belgium (25 to 50 km).

No transboundary effects are therefore expected for the environmental aspect of water.

9.5 Extrapolation of the environmental situation

For water as an environmental aspect, this subsection describes future developments and their impact on the current environmental situation and operation of the nuclear power plant.

9.5.1 Anticipated developments

9.5.1.1 Climate change

Sea levels are rising due to climate change and precipitation is less predictable, with drier summers and wetter winters (extreme weather events). These changes may affect operations at the Borssele nuclear power plant. Changes in water temperature have implications for the period (the number of hours or days per year) during which restrictions on cooling water discharge apply. We briefly discuss the consequences due to future developments for the aspects of temperature, salinisation, drought and flooding.

Temperature

If greenhouse gas emissions continue at the same rate, the Earth (including its oceans and rivers) will get warmer and warmer, with major ramifications for mankind, nature and the environment. Water, especially the oceans, heats up more slowly than land does. The water temperature in the Scheldt near Vlissingen fluctuates between approximately 4°C and 22.5°C each year (see Section 9.4.2). The measurements are showing evidence of an average trend (increase) of 0.06°C per year. The average water temperature in 2030 will be higher than the average temperature in 2023.

Higher, prolonged, temperatures can damage the natural environment. The maximum daytime temperature at which there is little or no damage is around 28°C. Water temperatures in the North Sea are currently rising at a rate of between 0.023°C per year in the northern part and 0.053°C per year in the central and southern parts (Klimaat.be, 2024). Rising water temperatures are affecting the natural environment as well as the functioning of the nuclear power plant. It may become more difficult to use seawater for cooling because of rising water temperatures. This may result in the permitted water extraction being limited. This has consequences for the functioning of the nuclear power plant (Strackx, 2018; Linnerud, 2011). In addition, discharging water from the cooling water system may also become problematic since it leads to the discharge of more heat into river water that is already warm. This may have consequences for the natural environment, particularly in the mixing zone (see Chapter 6). Furthermore, the permit sets out limits for the background water temperature; see Section 9.3.1 Water quality and the permit (Rijkswaterstaat Zee en Delta, 2014) for more information.

Salinisation

Climate change is raising the concentration of salt in surface water (external salinisation) as well as groundwater (internal salinisation) and the soil, due to the rise in sea levels, the subsiding soil and more frequent and longer hot and dry periods. The increase in salinisation (or: the salt load) in this area can be seen in the Climate Impact Atlas. If water salinity remains high, it has negative effects on water quality and therefore the natural environment and the use of water for drinking water and agriculture, for instance (Kennisportaal Klimaatadaptatie, 2024). Salinisation does not have a direct impact on the operations at Borssele nuclear power plant. Indirectly, slightly higher salinity in the groundwater will affect the salt load of the emergency cooling system. Measurements show that any increase in salt through the emergency systems will remain well below the amount of chloride allowed under the permit. The nuclear power plant is not contributing to salinisation by using groundwater for emergency cooling.

Drought

Due to climate change, we are having warmer, drier summers more frequently. This is causing drought and a drop in surface and groundwater availability. This has a negative impact on water quality as well as water quantity. Prolonged drought and water shortages lead to deployment of the displacement series (KNMI, 2024). Nuclear power plants and nuclear reactors are classified in Category 3 (after water safety in preventing irreversible damage and utilities) in the displacement series (Rijkswaterstaat, 2024). The deployment of the displacement series may lead to the limitation or ban on extraction of surface and groundwater. Any future restrictions regarding the extraction of saline and other groundwater may affect the availability of the emergency cooling water system of the nuclear power plant (ANVS, 2023).

As far as the Western Scheldt water system and the nuclear power plant are concerned, incoming river water does not affect the tidal flow at the inlet and outlet. This means that a shortage of river water (during a drought) does not affect the functioning of the normal intake of cooling water.

Flooding

Water safety policies in the Netherlands take climate change into account by assessing the load on dykes through high water levels every six to twelve years. Since 2017, flood defence systems have been assessed based on standards (probability of flooding). The speed at which the sea level will rise is not certain. Based on the Royal Netherlands Meteorological Institute's *KNMI'23 climate scenarios* for 2050, the expected rise in sea levels for the North Sea coast is 16 to 38 cm compared to 2020. In the Western Scheldt, a water level rise of 20 to 30 cm is expected in the period up to 2050 for the 'high' scenario (Klimaateffectatlas, 2023). The Western Scheldt is completely behind dykes, without storm surge barriers because of the ports and increasing shipping activity. The combination of dykes, salt meadows and mud flats/salt marshes protects the islands in Zeeland (ENW-Advies, 2019). Water safety related to the protection of the Borssele nuclear power plant is discussed in greater detail in Chapter 8 Nuclear Safety.

The Climate Impact Atlas has maps that show the likelihood of flooding. An extremely small probability must be taken into account at the plant (< 1/30,000 per year) that a layer of about 2 metres of water may end up on parts of the site.

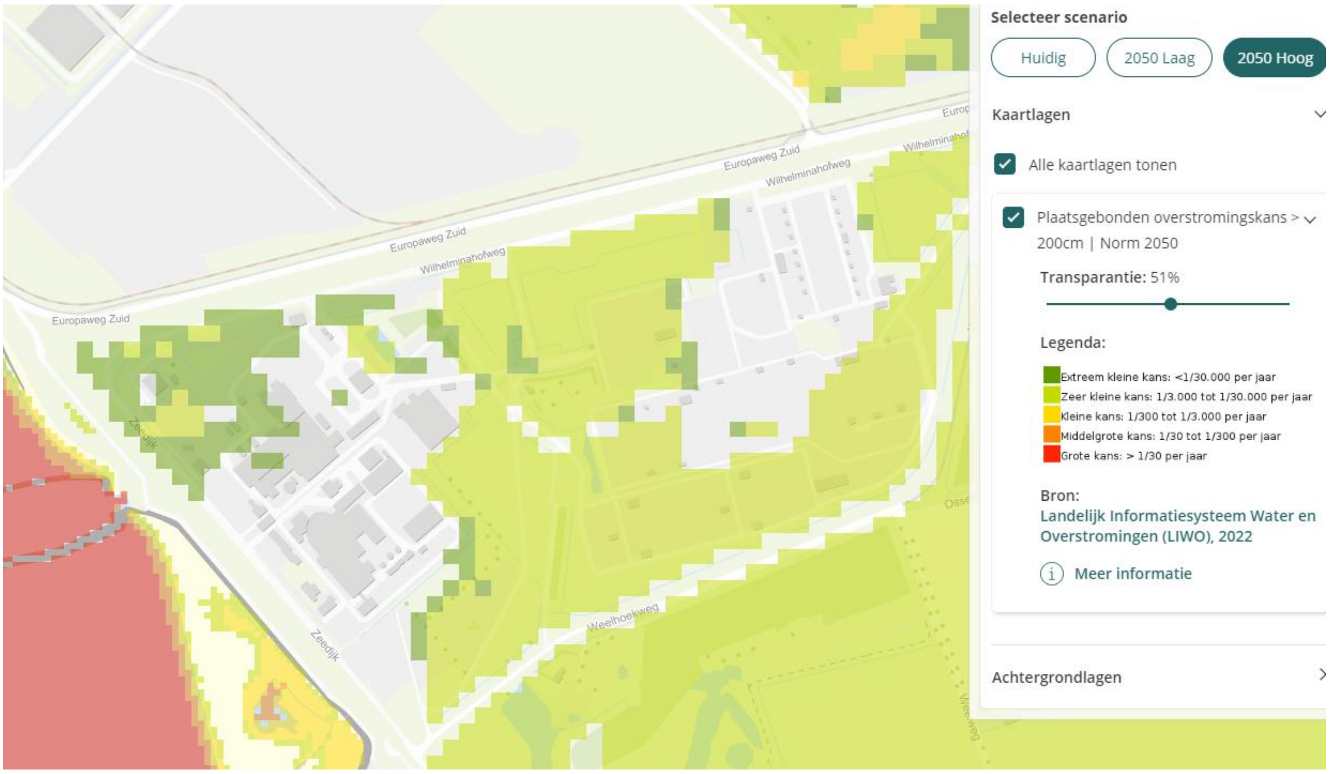


Figure 9-6 Likelihood of localised flooding > 200 cm, 2050 standard (source: National Water and Floods Information System 2022 and the Climate Impact Atlas)

Extremely heavy showers will occur more frequently due to the heating of the atmosphere. The drainage system on the site generally does not have enough capacity to drain away the runoff from heavy showers immediately. The Climate Impact Atlas shows which parts of the site will temporarily have a water layer of 20 cm or more. As far as operations are concerned, it is advisable to investigate whether buildings have sufficiently high barriers to prevent local inundation.

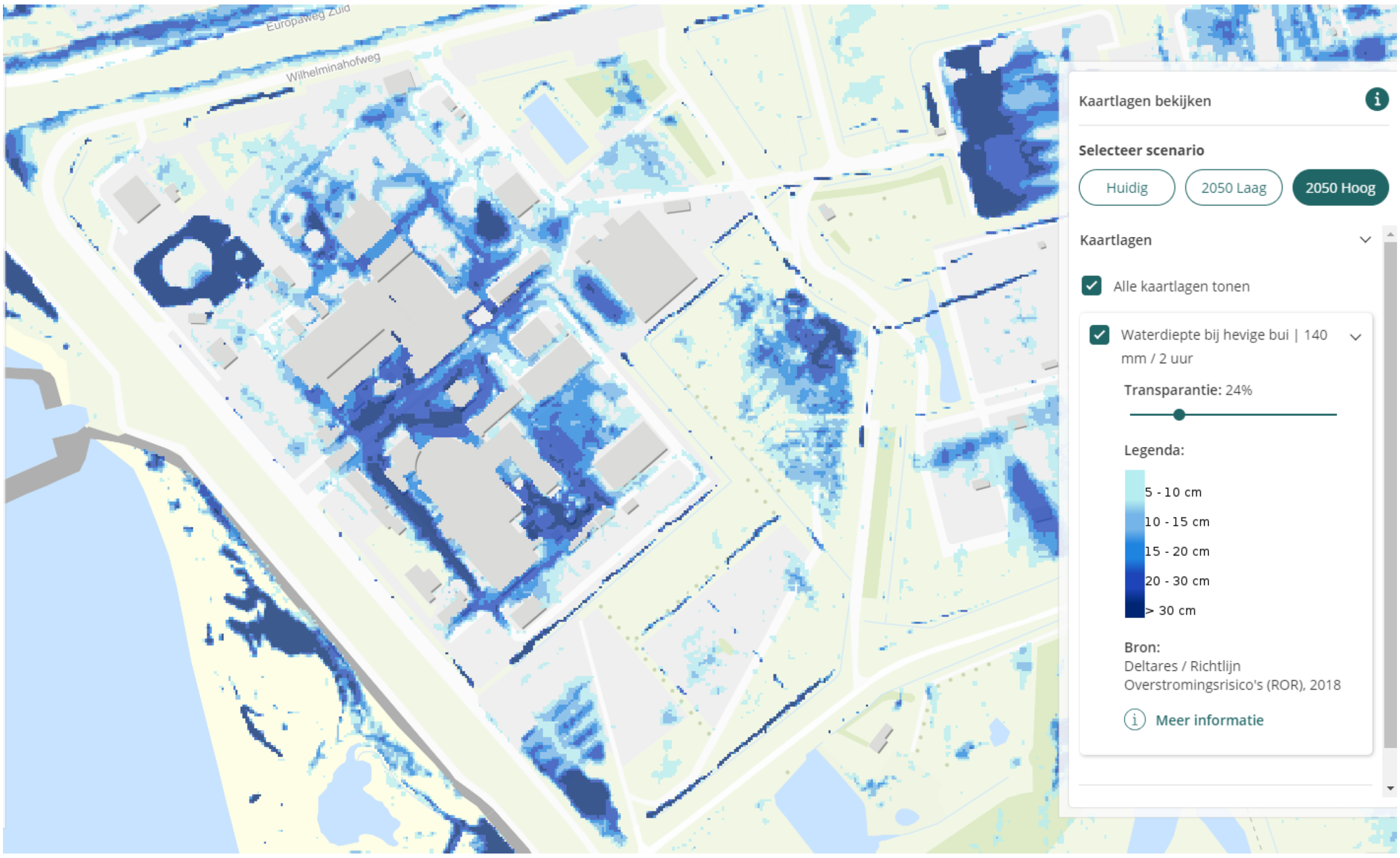


Figure 9-7 Depth of the water in the event of a heavy shower (140 mm in 2 hours). Source: Deltares, Guidelines for flooding risks, 2018 and Climate Impact Atlas

9.5.1.2 Recreational use of the Western Scheldt

Climate change may also have a negative effect on recreation, particularly because of the effect on water quality. One bathing water site, the Kaloot, is located immediately west of the Borssele nuclear power plant and south of Sloehaven. The bathing water site is delineated by rockfills from the adjacent cooling water outlet of Borssele nuclear power plant (Tauw / RPS, 202).Higher temperatures due to climate change will also trigger an increase in the temperature of surface water. Discharging cooling water from the nuclear power plant will exacerbate this. In addition, concentrations of chemical and other substances in the water increase, especially during droughts and periods of low discharge (the dilution effect). This may have negative implications for the quality of bathing water in due course (Kennisportaal Klimaatadaptatie, 2024).

9.5.1.3 Further development of nuclear energy alongside the Western Scheldt

The government intends to build two new nuclear power plants at Borssele. It is likely that future power plants will also use the Western Scheldt for heat discharge. The cumulative effects of this heat discharge will be investigated further during the preparations for the new nuclear power plants. The discharge permit states that environmental restrictions apply to the amount of heat that may be discharged during periods when the water temperature is high. The discharge flow rate and heat discharge is reduced during periods of high water temperature by reducing electricity generation. The duration and frequency of periods of restrictions will increase due to global warming. This may have consequences for operations at the nuclear power plant. See Section 9.3.1 Water quality and the permit (Rijkswaterstaat Zee en Delta, 2014) for more information about restrictions related to the temperature of the water. The plants built in the future and the existing plant will use the same water. It is plausible that all power plants along the Western Scheldt may have to simultaneously produce energy using less power or not at all when restrictions are in place. The restrictions will apply to the existing Borssele plant, the Doel plant in Belgium and the plants built in the future.

9.6 Outlook for EIA Phase 2

During EIA Phase 2, it will be clear whether any technical adjustments to the nuclear power plant are necessary. In this subsection, the knowledge gaps are identified and the follow-up studies and environmental focal points for the next step (Phase 2) have been placed on the agenda.

9.6.1 Key environmental focal points

Water quality is the main environmental concern for water as an environmental aspect. A water emission test for any future granting of a permit will provide detailed insight into the effects of the cooling water discharge on the water quality of the Western Scheldt. In addition, modelling of the heat plume and discharge plume is needed to gain a better understanding of the extent of cooling water discharge effects.

It is important to include the current warming of the Western Scheldt and future warming in the parameters for the model calculation of the heat plume.

The boundary of groundwater, water systems behind the dyke and national waters is difficult to indicate. In many studies, the influence on the water environment is restricted to the edges where the effects are logically absent or present in minimum percentages. A conceptual model of the extraction and discharge of water volumes by the Borssele nuclear power plant in relation to the water environment will help to investigate the limits to which impacts may occur.

The effects of silt dredging on the intake and the movement of potentially contaminated dredge spoil within the Western Scheldt estuary can be investigated and tested in Phase 2 using the current assessment frameworks for waterbeds.

10 Health and safety

10.1 Introduction

There are several aspects to the subject of safety in the context of nuclear power plants. The most familiar are aspects concerning nuclear safety and radiation protection during regular operations. These subjects are discussed separately in Chapters 7 and 8.

Apart from the primary process, i.e. the generation of energy using nuclear power, the Borssele nuclear power plant (hereinafter referred to as 'KCB') has various processes, such as those for cooling, the emergency power supply, heating and water treatment, all of which support the primary process. These processes are referred to as 'conventional processes' in this section and conventional (i.e. non-nuclear) environmental aspects are linked to these processes. Under normal operations at KCB, levels of these conventional emissions are low in the environment where they could potentially pose a risk to humans and animals. This section discusses health and safety risks. The management and regulation of these conventional substances and of radioactive substances is laid down in a permit (EPZ Revision Permit, 2016). The EPZ accounts for the conventional environmental aspects each year in its annual environmental reports.

In this section, we describe the legal frameworks and criteria that apply for the assessment of the effects of conventional environmental aspects and (non-radiological) health aspects, as they are outlined below. This chapter gives an overview of:

- The relevant policy frameworks for the environmental aspects.
- Current operations and the impact on the environment. These factors are compared with the standards and threshold values stated on the permit and policy frameworks (if applicable).
- The cross-border effects of the current environmental situation at the nuclear power plant on health and safety as environmental aspects.
- The external factors that could influence current KCB operations, such as climate change, and other changes in the direct vicinity and the environment further away.
- Knowledge gaps and environmental aspects for Phase 2.

Types of safety

Generally speaking, the perception is that nuclear power plants have a major impact on external safety. This is often linked to the perception that they could potentially cause an emergency or major disaster. For nuclear power plants, such a calamity would be due to a nuclear incident. Individual and group risks posed by the nuclear power plant are also safety issues. At KCB, these aspects are linked to nuclear safety (Chapter 8), and are therefore discussed in that section. The link with the National Radiation Crisis Plan is also included in that section.

Other operations are very limited in scope from an external safety perspective. The aspects concerning the hazards inherent to conventional operations are similar to operations that are classified as having a light safety profile. The quantity of hazardous substances in the non-nuclear part of the KCB is such that regulations such as the Dutch Major Accidents (Risks) Decree [*Besluit risico's zware ongevallen*] do not apply to it.

10.2 Relevant policy frameworks

The legislation and regulation frameworks listed below are important for the area surrounding KCB.

Table 10-1 Legal and policy frameworks for health and safety

Policy, legislation and regulations	Contents and relevance
Environmental Management Act	Various regulations provided for in the Environmental Management Act have been amended or repealed since the entry into force of the Dutch Environment and Planning Act [*Omgevingswet*] on 1 January 2024. An important change is that the term 'establishment' ceases to be used. Chapters 3 to 7 (international affairs, plans, environmental quality requirements, environmental zoning, environmental impact report) have also ceased to have effect. The existing rights and obligations regarding the (external) safety of the KCB have their roots in the regulations based on the Environmental Management Act.
Living Environment (Activities) Decree	Environmental regulations for companies are laid down in the Dutch Living Environment (Activities) Decree [*Besluit activiteiten leefomgeving*] in the system of regulations under the Environment and Planning Act. Government regulations are laid down in the decree for activities in the physical living environment, for instance, regulations concerning the natural environment, cultural heritage and airports. This decree replaced the Dutch Activities (Environmental Management) Decree [*Activiteitenbesluit*]. The Environment and Planning Act defines what constitutes an environmentally harmful activity and the decree states which environmentally harmful activities are subject to government regulations. In addition, the decree mentions whether those environmentally harmful activities require a notification or an environmental permit, and who the supervisory authority is.
Environment and Planning Act	In the context of external safety, the Environment and Planning Act emphasises the risk management that may be required due to operations involving hazardous substances, such as industry or transport. The act lays down criteria for spatial planning to minimise the risks to those living in the vicinity and provides regulations for establishing safety distances between high-risk operations and vulnerable objects, such as homes and schools. The aim is to ensure external safety by integrating risk management into the planning and development of the living environment.
-	As far as amendments to the legislation are concerned, there are no general important policy frameworks relating to health in relation to non-radiological aspects.

10.3 Criteria

Environmental aspects related to health and safety are examined in this section. For conventional (external) health and safety aspects, this concerns the points given below in Table 10-2.

Table 10-2 Criteria to be assessed

Criteria to be assessed	Explanation
Hazardous substances	The substances stored in the PGS 15 (Publication Series on Dangerous Substances) storage, i.e. coolants and various industrial gases
Failure of conventional systems, including steam and generators	The impact that the failure of generators has on conventional operations
The potential risks of extinguishing gas	Managing fire and its effects on conventional operations
Emergencies and emergency management	The preparation for and response to emergencies for conventional operations
Perceptions of health and safety	The impact of the presence of KCB on health and the living environment

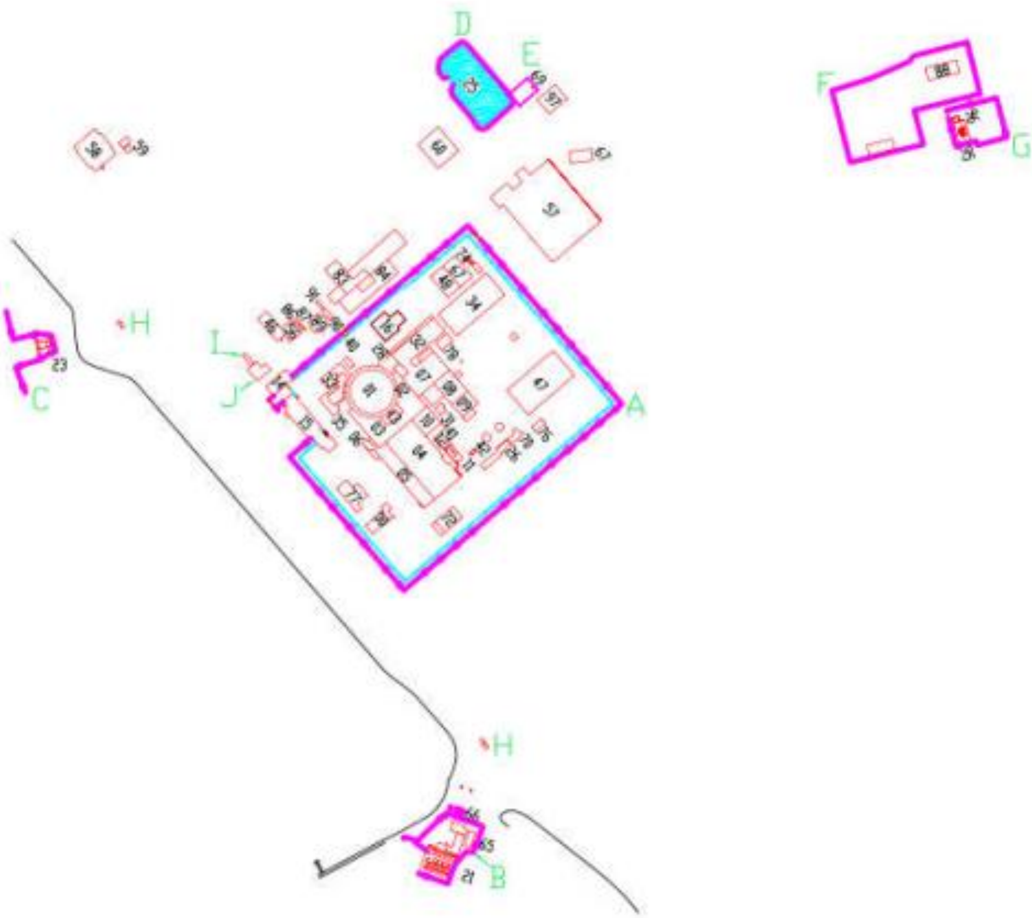
10.4 Description of the current situation

The 2015 Safety Report stated that analyses were carried out for all relevant conventional environmental aspects in accordance with the Integrated Environmental System (the IMS). These analyses focus on environmental impacts and risks for which an overview of environmental aspects is available.

The associated management methods are outlined in the overview of environmental aspects. These methods help ensure that the environmental impacts in question are prevented or kept as low as reasonably possible. The overview of environmental aspects and the adequacy of the management are periodically checked. Further substantiation of the risk analysis and the chosen management method is given in the documents setting out these environmental aspects and management methods. In principle, the sequence followed for this is: *tackling the issue at source – minimising the impact – mitigation measures*.

10.4.1 Hazardous substances

An overview of all chemicals present at KCB is given in the safety report. The safety report also states that storage facilities for these substances are available at two locations in the cooling water intake building (Building 21), at the various laboratories (Buildings 3, 8 and 15), in the carpentry workshop (Building 16), in the metal workshop (Building 8) and in the controlled area (Buildings 2 and 3). Any hazardous emissions that are released from these substances, during normal operations as well as during emergencies, are also mentioned. See Figure 10-1 for the layout of the buildings at the KCB site.



Installaties en voorzieningen op 'KCB-terrein'	Installaties en voorzieningen op 'KCB-terrein'	Installaties en voorzieningen buiten 'KCB-terrein'	Installaties en voorzieningen buiten 'KCB-terrein'
01 Veiligheidsomhulling	30 Hondenkennel	14 Bewakingsloge	86 Voedingstrafo's
02 Reactorgebouw ringruimte	31 liftgebouw	15 Kantine/aanmeldbureau	87 Voedingstrafo's
03 Reactorhulpgebouw	32 Kantoorgebouw	21 Koelwaterinlaatgebouw	88 Opslaggebouw mobiele alarmresponsmiddelen
04 Machinegebouw	33 Reservesuppletiegebouw	23 Koelwateruitlaatgebouw	89, 90, 91 Lage druk brandblussysteem en
05 Schakelgebouw	34 Afvalopslaggebouw	46 Hulpstoomketels	waterplan
06 Dienstgebouw	35 Reserveregelzaalgebouw	56 BF-rail en drinkwatervoorziening	97 Twee Romney loodsen
07 Werkplaats EMRA/mechanisch	40 10 kV station	57 Magazijn	
08 Archief/Tekenkamer/conv lab	41 Starttransformator	58 Kantoor en SODAR apparatuur	Overige installaties en bedrijfsterreinen
09 Deminwateraanmaakgebouw	42 Hydrazine-voorraadtank	59 Was- en kleedruimte	A buitenhek 'beveiligd gebied KCB'
10 Noodstroomdieselgebouw I	47 Opslagloods	60 Opslag (gevaarlijke) (afval) stoffen	B terrein koelwaterinlaat
11 Machinetransformator	G48 Brandweerkazerne	65 Kantoorgebouw KWI	C terrein koelwateruitlaat
12 Starttransformator	67 Was- en kleedruimte	66 Opslagloods KWI	D blusvijver (25)
13 Ventilatieschacht	70 Olieopslaggebouw	67 Nissenhut	E oefenplaats voor de brandweer met opslag (69)
14 Bewakingsloge	72 Noodstroomdieselgebouw II	83 WPS, evt regelzaalsimulator	F vliegasterrein met ontwateringsbak mosselen
15 Kantoorgebouw	74 Noodstroomdieselgebouw EY060	84 Kantoren, 'hoge werkplaats'	G terrein met 380 kV transformator (95, 96)
16 Werkplaats civiel	76 AT-trafo opslaggebouw		H dijkhuisjes (4 stuks)/koelwaterleidingen
26 Gasflessenopslag	77 Kantoorgebouw		I aardgasontvangststation
28 Cementsilo	78 Kantoorgebouw		J fietsen- en motorenstalling

Figure 10-1 KCB buildings (indicative)

The chemicals are types of coolant R22 (about 12 kg), R134A (about 1220 kg) and R410A (about 43 kg) in the cooling equipment linked to the system (UV), and R22 (about 15 kg), R407c (about 110 kg) and R410A (about 52 kg) in the other cooling equipment not linked to the system. Bulk chemicals such as hydrochloric acid, sulphuric acid, caustic soda, hydrazine and chlorine bleach lye, diesel oil and lubricating oil are also present. The third group of chemicals present at the site includes industrial gases in cylinders (in Building 26) such as acetylene, argon, helium, methane, Protegon, nitrogen, hydrogen and oxygen.

The annual environmental report gives an account of the results each year. Based on the information given in the annual reports, it follows that KCB operates within the limits of its permit as far as these conventional aspects are concerned. Emissions from the various substances are within the permit requirements. It follows from this that there are no hazards or risks attached to the hazardous substances aspects.

10.4.2 Failure of the conventional system: Generators

The functioning of the emergency power generators is included in the conventional part of the nuclear power plant. However, the malfunctioning or failure of these generators only affects the nuclear part of the plant. The conventional systems are not exposed to hazards or risks if these emergency generators fail. A description of the generators' impact on the conventional safety of the nuclear power plant is therefore not necessary.

10.4.3 Fire

Cylinders containing Inergen extinguishing gas are stored in various rooms in Buildings 03, 05, 10 and 21. A typical stock of Inergen amounts to 13,040 litres (divided across cylinders with maximum capacity of 80 litres). Approximately 120 kg of CO_2 used in the CO_2 extinguishing system is also stored in gas cylinders in Building 04.

The fire brigade barracks (Building 48) serves as a garage for various fire brigade vehicles. There are several stockpiles (including in 60-litre steel drums) of foaming agent on the KCB site. The total amount is around 1,000 litres.

There is also the KCB Alarm Plan, which includes an attack plan for the emergency services in the event of an emergency. It follows from this that there are no hazards or risks attached to the aspects of hazardous substances, fire and emergencies. (This is in line with the management methods and the attack plan.)

10.4.4 Emergencies and managing emergencies

The KCB has an alarm organisation. Run by line officers, this organisation is responsible for creating, maintaining and training the emergency response organisation, and running alarm response drills under normal operating conditions. The aim behind all of this is to be prepared and able to act appropriately in the event of an emergency. The alarm plan and the emergency response organisation is assessed annually. The findings from separate evaluation reports of all the drills held in that year are used as input for the annual reports.

10.4.5 Perceptions of health and safety

Based on information from the annual reports, current operations have no impact on (external) health and safety in the vicinity of the KCB in terms of the conventional environmental aspects. The impact on health effects as far as the nuclear part is concerned are described in Chapter 7 Radiation Protection and Chapter 8 Nuclear Safety. This section focuses on the perception of safety at the nuclear power plant.

The EPZ environmental reports state that one complaint was received from someone in the surrounding area in the period between 2018 and 2022. This complaint concerned the washing up of Taprogge balls on the beach; the origin of these balls has not yet been established. KCB is investigating whether they may have come from the processes at the plant. The fact that there have been no other complaints is an indication that KCB's presence is not having a negative impact on the surrounding area.

Based on their 2023 Perceptions survey,[44] Statistics Netherlands have ascertained that 36 per cent of adults believe that the Netherlands should use more nuclear energy. In 2020, this figure stood at 25 per cent. It is mainly men, the elderly and the highly educated who are proponents of nuclear energy. There are also regional differences. Those living in Zeeland, where the only nuclear power plant is located, are the most positive about nuclear power.

[44] The 2023 Perceptions survey was conducted from 7 February until 21 April. It examined the opinions that people in the Netherlands hold about climate change and the energy transition. Related issues such as sustainable living, sustainable mobility, sustainable food and climate-conscious lifestyles were also surveyed. More than 18,000 adults took part in the research. More Dutch citizens in favour of nuclear energy | Statistics Netherlands

In 2020, 25 per cent of Dutch people aged 18 and over believed the use of nuclear power should increase, 18 per cent thought it should decrease, while 25 percent were completely against it. In 2023, support for more nuclear energy has risen to 36 per cent, 12 per cent say it should be reduced and 15 per cent wants it banned. The overall public opinion about nuclear energy has therefore become more positive over the past three years.

Noise and air pollution

As described in Chapter 12 Noise, there are several sources of noise at the KCB site. Every five years, noise levels are measured at various measurement points to check compliance with the stipulated criteria for noise. KCB complies with its prevailing noise regulations by a wide margin, which means KCB is not responsible for any additional noise pollution (in the surrounding area).

The impact that KCB has on air quality may be caused by operating emergency facilities and incinerators, and traffic to and from the plant. Given KCB's extremely limited emissions (NO_2 and PM_{10}), no relevant impact on local air quality is expected, particularly when one compares it to emissions from other sources in the vicinity.

10.4.6 Transboundary effects

Given that there are no local effects from the conventional aspects of external health and safety, no transboundary effects are expected either.

10.5 Extrapolation of the environmental situation

10.5.1 Expected developments and extrapolation

For the conventional aspects of external health and safety, this subsection describes expected developments and their impact on the current environmental situation and operation of KCB.

Climate

The anticipated developments and effects of climate change on conventional health and safety aspects are the same as those described in Chapter 7 Radiation Protection, Chapter 8 Nuclear Safety and Chapter 9 Water.

Borssele Energy Hub

Several developments are under way in the immediate vicinity as a direct result of the energy transition, as outlined in Section 2.4. As a result, the site around the KCB is also known as the 'Borssele Energy Hub'. The Borssele Energy Hub has no impact on conventional environmental aspects at KCB.

10.5.2 Extrapolation

At this point in time, there are no developments that warrant a foreseeable change in policies regarding the conventional aspects discussed in this section, nor are any changes to be expected in the effects of conventional aspects if operations continue as they are.

10.6 Outlook for EIA Phase 2

During EIA Phase 2, it will be clear whether any physical adjustments to the nuclear power plant are necessary. No bottlenecks and/or knowledge gaps have been identified as environmental focal points for EIA Phase 2.

11 Soil

11.1 Introduction

For Phase 1 of the EIA, the current situation was described for the aspect of soil based on historical and current operations that may negatively affect the soil. This chapter focuses on environmental aspects of soil quality. The condition of the KCB site from a contamination point of view is discussed (Section 11.4). We first explain what the relevant policy frameworks encompass (Section 11.2). We then go on to explain how operating KCB for longer might affect the current condition of the site, particularly from a contamination point of view 11.5). We also shed light on the transboundary effects (Section 11.4.3). Finally, Section 11.6 examines how the aspect of soil should be dealt with in Phase 2, what the key considerations are in this regard, and whether any problem areas may arise.

11.2 Relevant policy frameworks

Table 11-1 below gives a summary of the legal and policy frameworks for the aspect of soil. Relevant legislative amendments were implemented with the entry into force of the Dutch Environment and Planning Act [*Omgevingswet*] on 1 January 2024.

Table 11-1 Legal and policy frameworks for soil

Policy, legislation and regulations	Contents and relevance
National laws and regulations	
Environment and Planning Act	The Dutch Environment and Planning Act [*Omgevingswet*] brings together the laws on the physical environment and determines the requisite follow-up actions regarding any soil contamination that may be present. • Everyone is obliged to take sufficient care of the physical environment under a general duty of care. • The secondary track for soil adds the themes of soil and subsoil to the Environment and Planning Act. The quality of the soil is taken into consideration when examining the quality of the living environment. • The Dutch Living Environment (Activities) Decree [Besluit activiteiten leefomgeving] sets out measures to protect the soil from environmentally harmful activities that may contaminate the soil (the excavation and the depositing of soil and dredge spoil).
Soil Protection Act	The Dutch Soil Protection Act [*Wet bodembescherming*] (3 July 1987) was incorporated into the Environment and Planning Act. The old legislation (1987 to 2023) falls under transitional law. There are various situations in which transitional law may apply: whether or not decision is serious and urgent, or serious but not urgent, whether or not a remediation plan has been submitted, whether or not a notification under the Dutch Uniform Remediation Standards Decree [*Besluit uniforme saneringen*] has been submitted, and so on.
Nuclear Energy Act	The Dutch Nuclear Energy Act [*Kernenergiewet*] provides for regulations aimed at protecting the soil from radioactivity.
National policy	
Water Framework Directive (2000) and the Groundwater Directive (2006)	The Water Framework Directive is a European directive that came into effect on 22 December 2000. Its objective is to achieve and maintain chemically clean and ecologically healthy surface and groundwater. The Groundwater Directive is a European directive that came into effect on 12 December 2006 with the aim of protecting groundwater against contamination and deterioration. The directive also specifies the chemical aspects for groundwater.

Policy, legislation and regulations	Contents and relevance
Local policy	
Soil quality map of the Municipality of Borsele, 6 October 2009	The soil quality map divides a soil management area into zones of similar environmental soil quality. These zones give the 'average' quality of these areas, apart from localised contamination caused by point sources.
Soil Management Memorandum, Municipality of Borsele, 4 September 2014	The Soil Management Memorandum is a policy document drawn up by the Municipality of Borsele for earthmoving and reuse of soil and dredge spoil. The memorandum describes the parts of the soil management area that are subject to the generic framework from the Dutch Soil Quality Decree [*Besluit bodemkwaliteit*] and for which areas an area-specific interpretation of the local soil policy is chosen.
PFAS Bevelanden and Tholen soil quality map, 24 November 2020	Supplementary to the soil quality map for the PFAS substance group.

11.3 Criteria

The current situation for the aspect of soil was described. The impact of the continuation of the nuclear power plant on the future situation was then examined. The current situation consists of two sections: activities that may be detrimental to the soil and the contamination situation.

11.3.1 Activities that may be detrimental to the soil

It is known that there have been historical activities and there are currently activities that may be detrimental to the soil at the KCB site. The current environmental permit, the permit under the Nuclear Power Act and the document on risks that the soil is exposed to describe activities that may be detrimental to the soil. The document on risks to the soil was drawn up in accordance with the requirements of the Dutch Soil Protection Guidelines 2012.

11.3.2 Contamination situation

Soil surveys have been carried out regularly since the nuclear power plant was built in the early 1970s. No information on the soil quality from before the construction of the nuclear power plant is known. Soil surveys, soil decontamination exercises carried out (remediation evaluations and care measures) and decisions dealing with soil quality together constitute the soil dossier. The soil dossier is used to describe the current contamination situation.

11.4 Description of the current situation

The current situation is described for the cadastral plot where the nuclear power plant is located, namely the plot known as 'Municipality of Borsele, Section A, number 1670'. The nuclear power plant is located on the plot, and the surrounding terrain is also on the same plot. A distinction has been made between the nuclear power plant itself and the remaining land within the cadastral plot (the immediate surroundings). Various activities have taken place in the immediate vicinity of the nuclear power plant: a coal-fired power plant northwest of the nuclear power plant and a fly ash repository east of the power plant.

The joint soil information system (**link**), used by the province of Zeeland, the Zeeland Regional Implementation Service and the affiliated Zeeland municipalities, was used as a source for the soil dossier. A soil survey report from this information system has been printed (Annex 4). The soil information system provides information about:

- Soil locations.
- Soil surveys.
- Contamination contours.
- Soil remediation contours.
- Decisions.
- Historical activities that may be detrimental to the soil.
- Underground and aboveground tanks.

Figure 11-1 gives a summary of the soil dossier, which is also given in Annex 5.

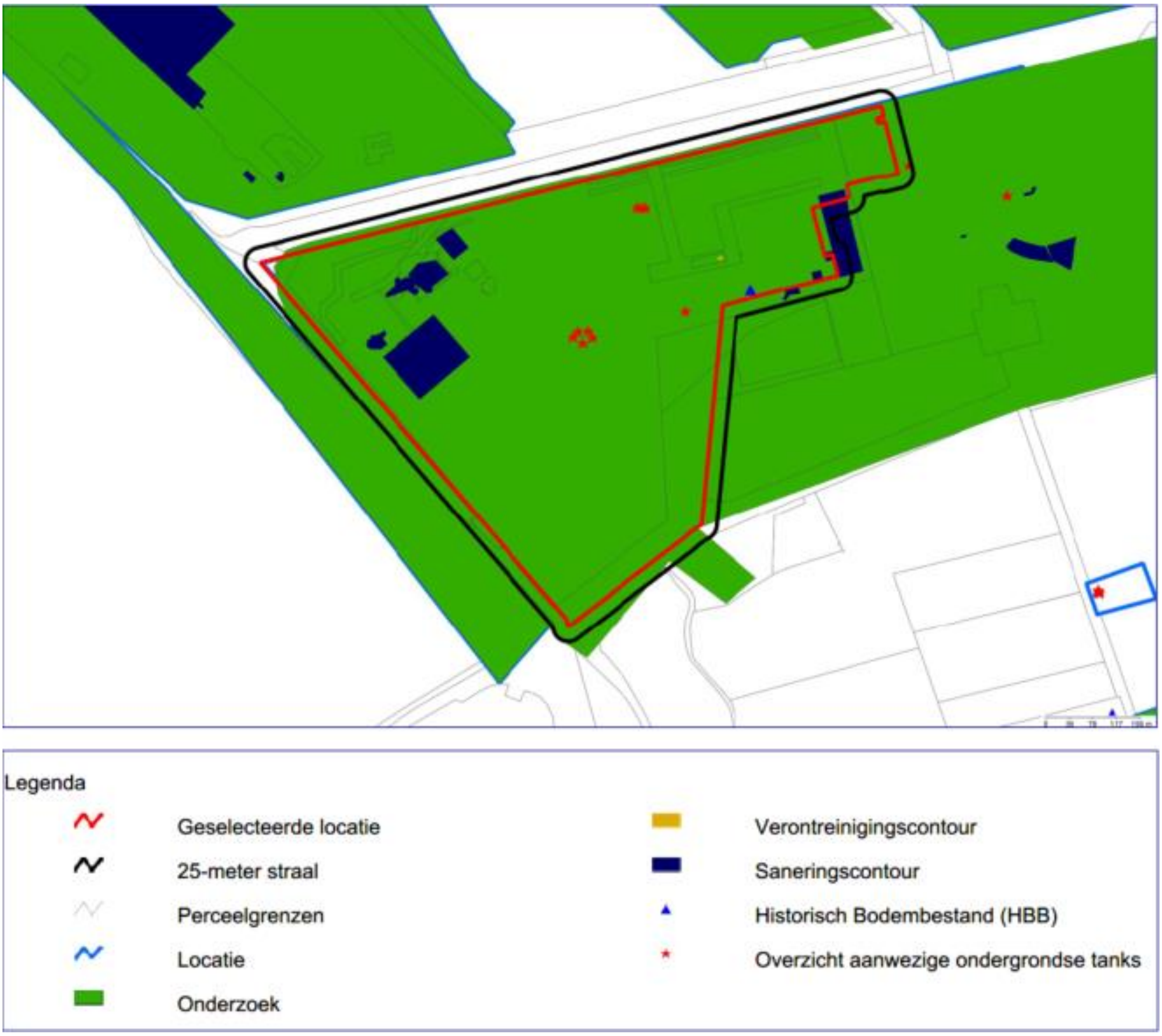


Figure 11-1 Summary of soil information according to the Zeeland Soil Survey Report

11.4.1 Activities that may be detrimental to the soil

The approved soil risk document[45] identifies and evaluates activities at the nuclear power plant that may be detrimental to the soil. The document also describes measures to be taken and provisions available if the risks that the soil is exposed to from existing measures and provisions are not negligible. EPZ has stated that the recommendations have been implemented. Based on the soil risk document, a negligible soil risk applies to all activities at the nuclear power plant that may be detrimental to the soil.

[45] Soil risk assessment and evaluation carried out by BMD Advies Zuid-Nederland, dated 7 March 2017, report number: LS/17.036/20051/DD

The soil dossier mentions several (underground) storage tanks in the immediate vicinity (see figure 11-2). All the tanks have been decontaminated and the certificates for this have been included in the soil survey report. Furthermore, the oil pipeline is mentioned as a specific activity. It is not clear from the soil dossier where this pipeline is located. In addition, no specific activities that may be detrimental to the soil are mentioned, but the activity is referred to as 'electricity production and distribution company'.

All soil survey reports available digitally deal with soil surveys at the site of the former coal-fired power plant in the immediate vicinity of the nuclear power plant. The activities that may damage the soil named in these reports are no longer being carried out, because the entire coal-fired plant was decommissioned in 2019. Therefore, there are no known historical operations beyond those mentioned in the soil risk document.

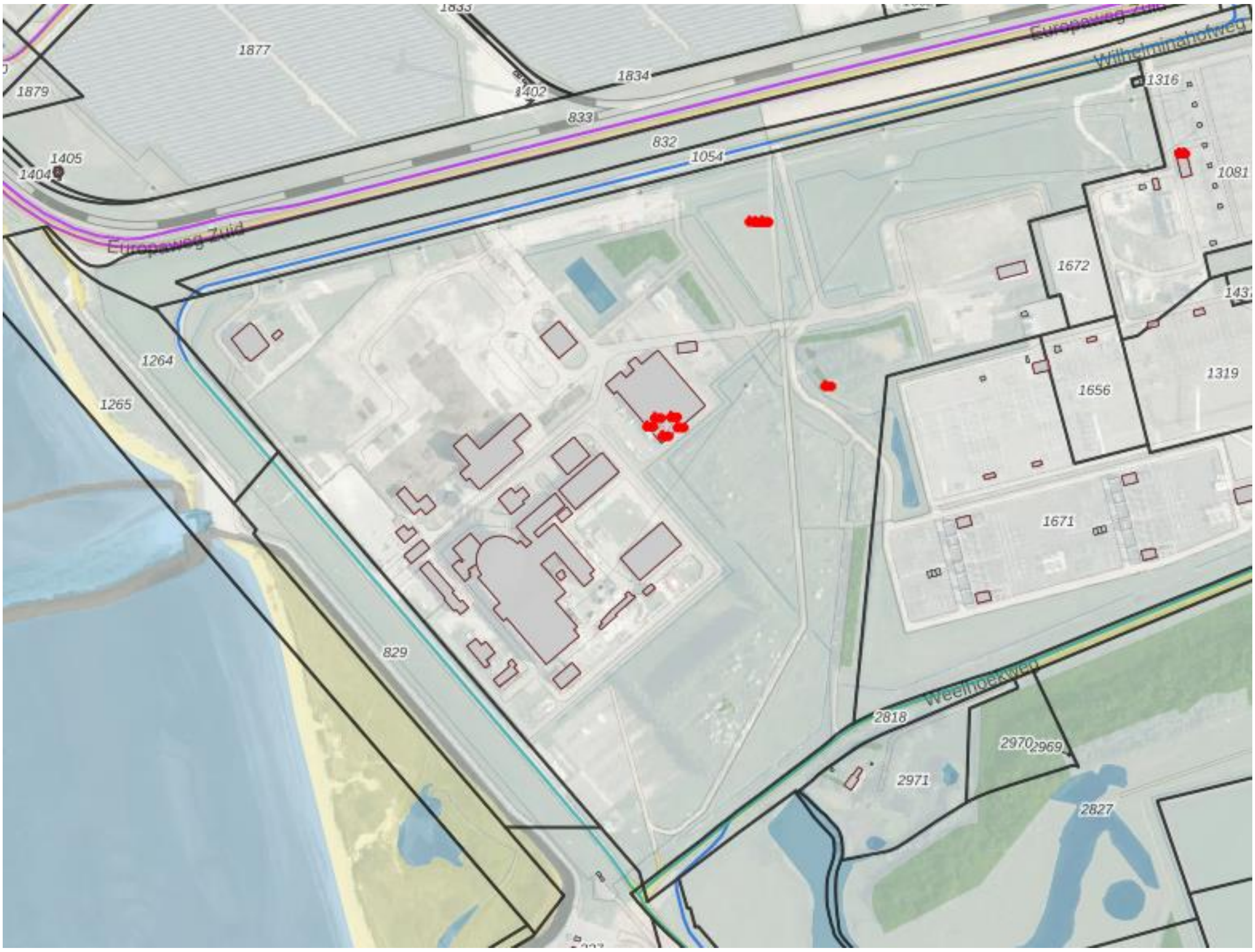


Figure 11-2 Locations of (underground) tanks (red) according to the Zeeland Soil Survey Report

11.4.2 Contamination situation

Several soil locations are given in the soil dossier. The overview in Annex 4 shows the status of the soil site. Most of the soil sites have been sufficiently investigated and do not require any follow-up actions.

This section elaborates on the soil sites that do require follow-up actions. In addition, the following aspects were investigated: the known contaminants that exceed the intervention level (Figure 11-3), the location of remediation contours (Figure 11-4) and whether the remediation work carried out has removed the contaminants.

- Soil sites 'Sea dyke 32 (EPZ)': There is an exploratory soil survey, remediation plan and monitoring report for this soil site. One exploratory soil survey, a remediation evaluation and three monitoring reports are known under a soil site of the same name but with 'Monitoring' as the status. An investigation and a monitoring exercise were carried out in the period from 1996 to 2003. In addition to the soil surveys, two decisions dated 22 April 1997 are known, which agreed to the remediation and groundwater monitoring carried out. Given the decisions and the period, this location is not an item for consideration in the context of the EIA.
- Soil sites at 'Borssele Coal-fired Power Plant': Most of the soil surveys are filed under this soil site (in the immediate vicinity of the nuclear power plant). The sub-sites have been included as separate soil sites for one soil survey carried out in 2015.[46] These combined soil sites include 11 heavy soil contaminations and one groundwater contamination. Various remediation exercises have been carried out since 2015. As a result, the status of the main soil site is 'sufficiently remediated' and the status of some sub-sites is 'conduct further investigation'. Several decisions concerning 'approve conducted remediation' also indicate that the heavy contaminants have been cleaned up.
- All contamination and remediation contours are situated outside the nuclear power plant site and are located in the immediate vicinity elsewhere on the cadastral plot. A comparison of the contamination contours (Figure 11-3) and the remediation contours (Figure 11-4) shows that there is no known remediation contour at the site of one of the contamination contours. This contamination is circled in red Figure 11-3. It concerns PAH contamination at the site of the former washing area of the fly ash repository (sub-site 3). The heavy PAH contamination in the subsoil was sufficiently contained (<25 m³) during the further soil investigation carried out in 2015.[47] Given that this contamination is located a good distance from the current nuclear power plant, it is not relevant to KCB's operations.

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[46] Exploratory soil survey Wilhelminahofweg (coal-fired power plant) in Borssele carried out by Antea Group B.V., dated 30 June 2015, report number: 401493.

[47] Further soil survey removal at coal unit BS 12 N.V. EPZ in Borssele carried out by Antea Group B.V., dated 9 July 2015, report number: 401493.02.

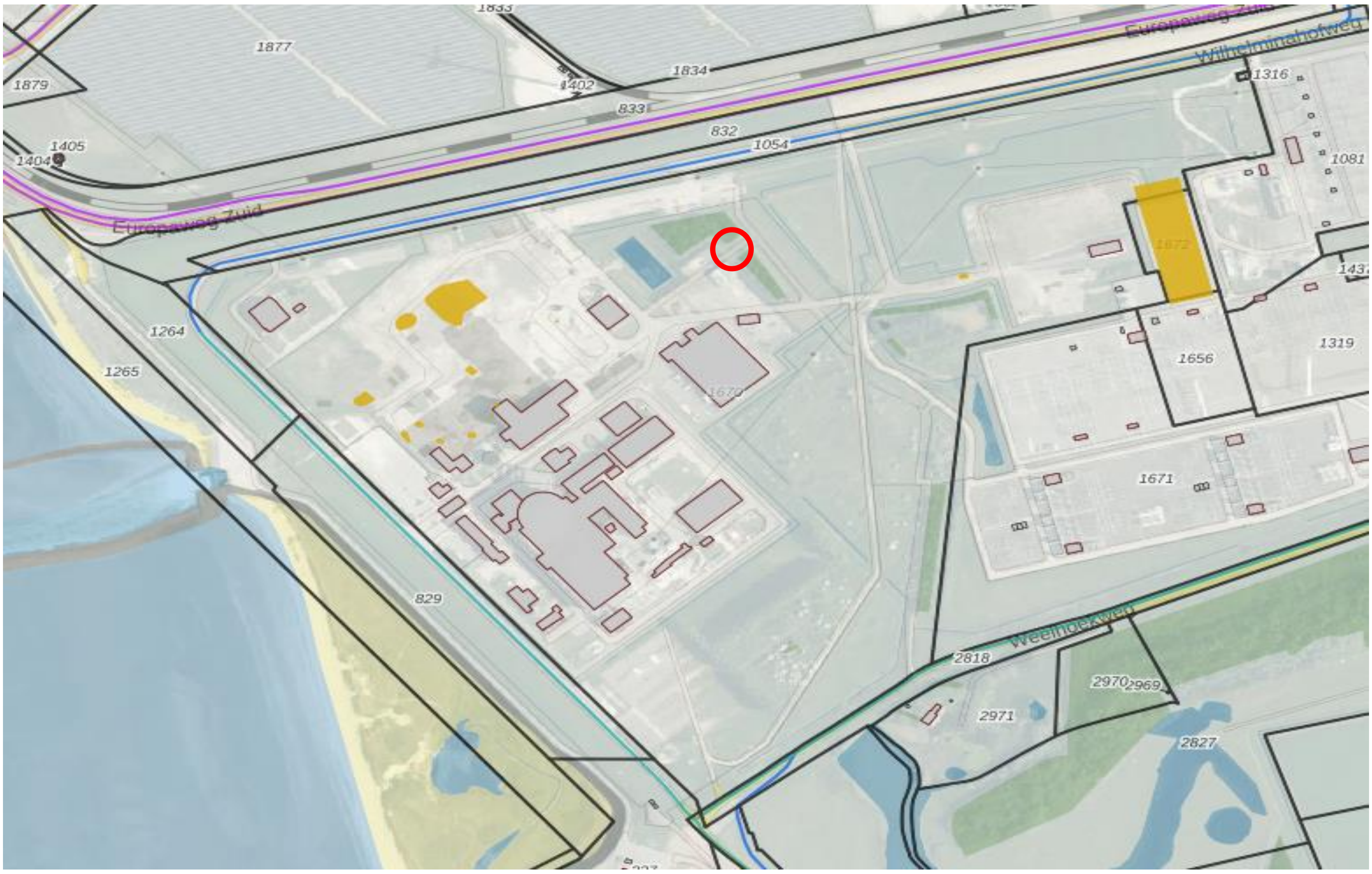

Figure 11-3 Contamination contours (yellow) according to the Zeeland Soil Survey Report

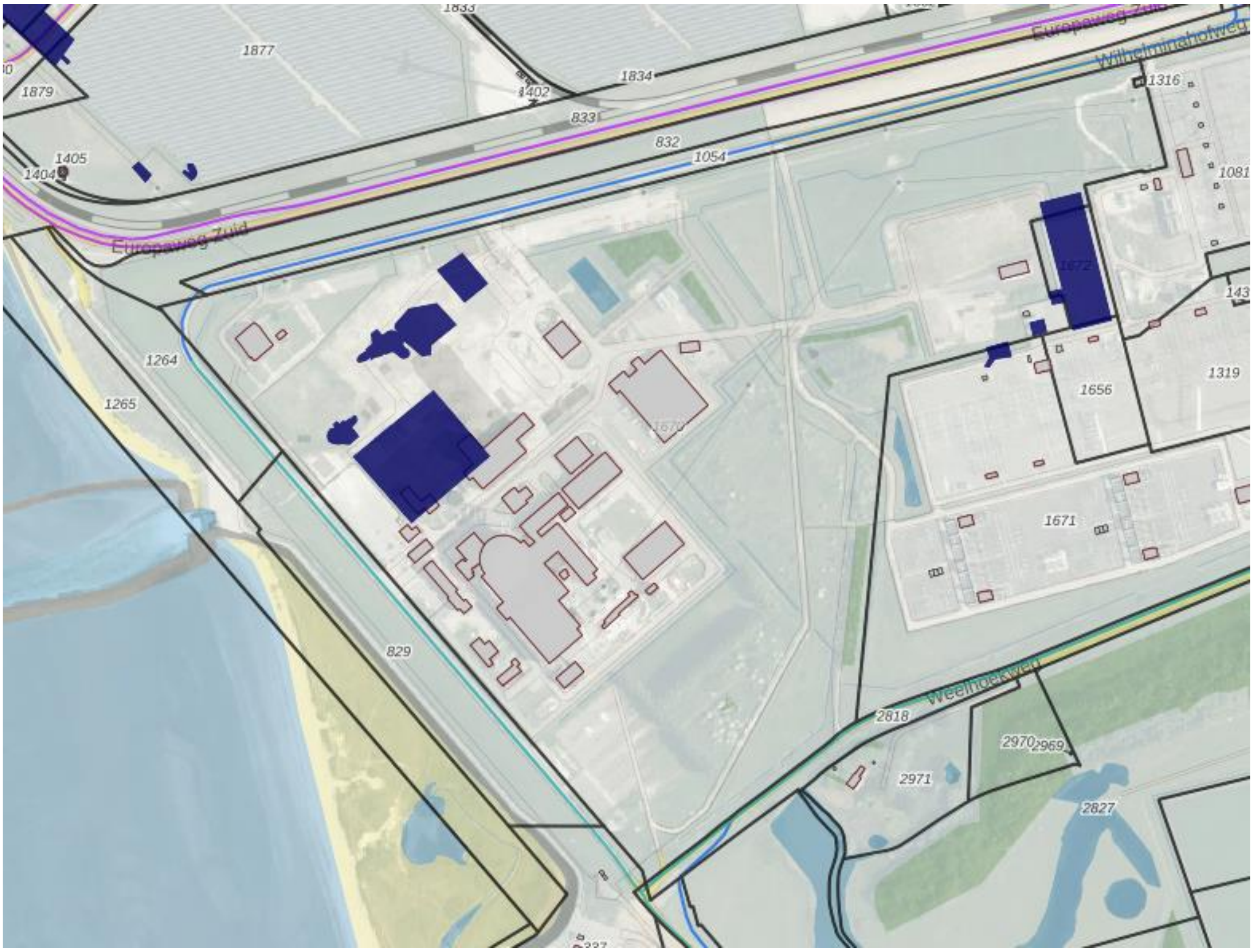

Figure 11-4 Soil remediation contours (blue) according to the Zeeland Soil Survey Report

11.4.3 Transboundary effects

For the soil aspect, the spread of groundwater contamination through groundwater flow is the only factor that may play a role when it comes to transboundary impacts. Two groundwater contaminations in the immediate vicinity of the nuclear power plant are known from the soil dossier. The first concerns mineral oil contamination at the site of the former coal-fired power plant. This was sufficiently cleaned up in the summer of 2021.[48] The second concerns arsenic contamination, as evidenced in a 2003 survey and as demonstrated during groundwater monitoring between 1987 and 2014. The 2014 monitoring report attributed the fluctuating arsenic concentrations to geochemical processes in the soil, which is not unusual in Zeeland.

48 Soil remediation report for sub-sites 30 and 41 EPZ in Borssele drawn up by Antea Group B.V., dated 25 November 2021, project number: 0442128.100.

The 2022 annual environmental report[49] also discusses groundwater quality. Tritium concentration levels in groundwater are monitored at the site. In 2022, no concentrations above the detection limit were detected in the process. The groundwater has been monitored since the remediation of groundwater at the location of the corrosion inhibitor spill (2010) at the nuclear power plant site. No abnormalities were determined in 2022.

Given the known groundwater contamination, transboundary impacts do not play a significant role for the aspect of soil.

11.5 Extrapolation of the environmental situation

11.5.1 Anticipated developments

No relevant developments are expected for the aspect of soil. The protection of the soil quality is provided for in the legislation and regulations in force. The 2022[5] annual environmental report found that EPZ must implement or maintain the measures taken and provisions available in accordance with regulation G.2 of the permit under the Nuclear Power Act. These measures and provisions are mentioned in the approved soil risk document.

As a result, these activities that may be detrimental to the soil have no consequences. The soil quality is therefore not expected to deteriorate in the future as a result of the operating life of KCB being extended.

11.5.2 Extrapolation

Given the prevailing legislation and regulations, the soil quality will not deteriorate. There is a duty of care should incidents or activities that may be detrimental to the soil demonstrably cause soil contamination. Soil contamination that arises after 2023 must be remediated.

11.6 Outlook for EIA Phase 2

During EIA Phase 2, it will be clear whether any physical adjustments to the nuclear power plant are necessary. The current soil risk document identifies and assesses all risks of KCB causing soil contamination . All measures and provisions have also been taken to reduce the risk of soil contamination. As a result, there are only negligible risks to the soil. Keeping KCB operating longer will not lead to a deterioration of soil quality in light of the current situation and the legislation and regulations concerning soil protection.

11.6.1 Key environmental focal points

Knowledge on PFAS, substances of very high concern and health is evolving and continues to do so. Looking beyond soil quality, there may also be requirements concerning the health of the soil (soil life), subsidence, compaction and/or salinisation.

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[49] 2022 Annual environmental report BS30 nuclear energy unit, drawn up by EPZ, dated 28 March 2023, reference: PO-N08-31.

12 Noise

12.1 Introduction

This chapter outlines the relevant policy frameworks and the criteria used for the assessment of the environmental aspect of noise. It also describes the current situation at the Borssele nuclear power plant for the environmental aspect of noise. In the process, the normative noise sources, the noise regulations in force and the occurring noise levels are discussed. This section mentions that no transboundary effects are expected. The extrapolation of the environmental situation is then described, and at the same time foreseeable developments and the future situation of the nuclear power plant are discussed. Finally, the outlook for the environmental focal points to be included for EIA Phase 2 is given.

12.2 Relevant policy frameworks

Table 12-1 gives the relevant policy frameworks for the environmental aspect of noise.

Table 12-1 Legal and policy frameworks for noise

Policy, legislation and regulations	Contents and relevance
Living Environment (Quality) Decree	The Dutch Living Environment (Quality) Decree [*Besluit kwaliteit leefomgeving*] sets out rules for environmental values, instructions and assessments, and rules for monitoring. This decree applies to the central government and local authorities. Environmental values for noise are laid down in the decree. These values still correspond to the values set out in the former Dutch Noise Abatement Act [*Wet geluidhinder*]. The Borssele nuclear power plant is located on the zoned Vlissingen-Oost Industrial Estate in the Municipality of Borsele. The combined noise level of all establishments on the zoned industrial estate must comply with a limit of a 24-hour average level of 50 dB(A) at the outer boundary of the established noise zone. There are many residential properties within the noise zone at the industrial estate. At the residences in the zone, the combined noise level due to all commercial operations on the zoned industrial estate may not exceed the established maximum permissible noise level or the established higher limit. The levels depend on the residence.
2008 policy regulation for the zone management system at the Vlissingen-Oost industrial estate, Province of Zeeland	The policy regulation governs the management of available noise zone at the Vlissingen-Oost industrial estate. As part of the policy regulation, the Provincial Executive of Zeeland adopted the ‘2014 acoustic development plan for Vlissingen-Oost Industrial Estate’ on 9 December 2014. This zoning plan regulates the actual layout of the noise zone at the industrial estate. To this end, the industrial estate has been divided into several areas. Each area has its own particular level, known as an area level, in the noise zone. An area level of 64.5 dB(A)/m^2 during the day and evening and 62.5 dB(A)/m^2 during the night has been set for the area where Borssele nuclear power plant is located.
Structures (Living Environment) Decree	The Dutch Structures (Living Environment) Decree [*Besluit bouwwerken leefomgeving*] together with the Dutch Living Environment (Activities) Decree [*Besluit activiteiten leefomgeving*] set out the general rules that members of the public and companies must comply with when carrying out certain activities in the physical living environment. This decree includes rules on noise, health, safety, the condition of the structure; sustainability and usability when building or refurbishing a structure; the use of the structure; and carrying out construction and demolition work.

12.3 Criteria

This chapter outlines the aspects that have to be investigated. Noise during the operating phase is particularly important for the extension of the operating life of the Borssele nuclear power plant. This concerns noise at sound-sensitive buildings and its incorporation into the noise zone. The assessment criteria for this aspect are given in Table 12-2.

Table 12-2 Assessment criteria for noise

Aspects	Assessment criteria
Noise at sound-sensitive buildings	The noise level at noise-sensitive buildings in the vicinity of the Borssele nuclear power plant.
Integration in noise zone	Integration in the current noise zone and limit values at residences and other noise-sensitive buildings in the noise zone, taking into account the combined noise of the other business operations at the zoned industrial estate.

12.4 Description of the current situation

12.4.1 Normative noise sources at Borssele nuclear power plant

The Borssele nuclear power plant (KCB) is located at the zoned Vlissingen-Oost industrial estate in the Municipality of Borsele. The location of the industrial estate and the current zone boundaries are given in Figure 12-1.

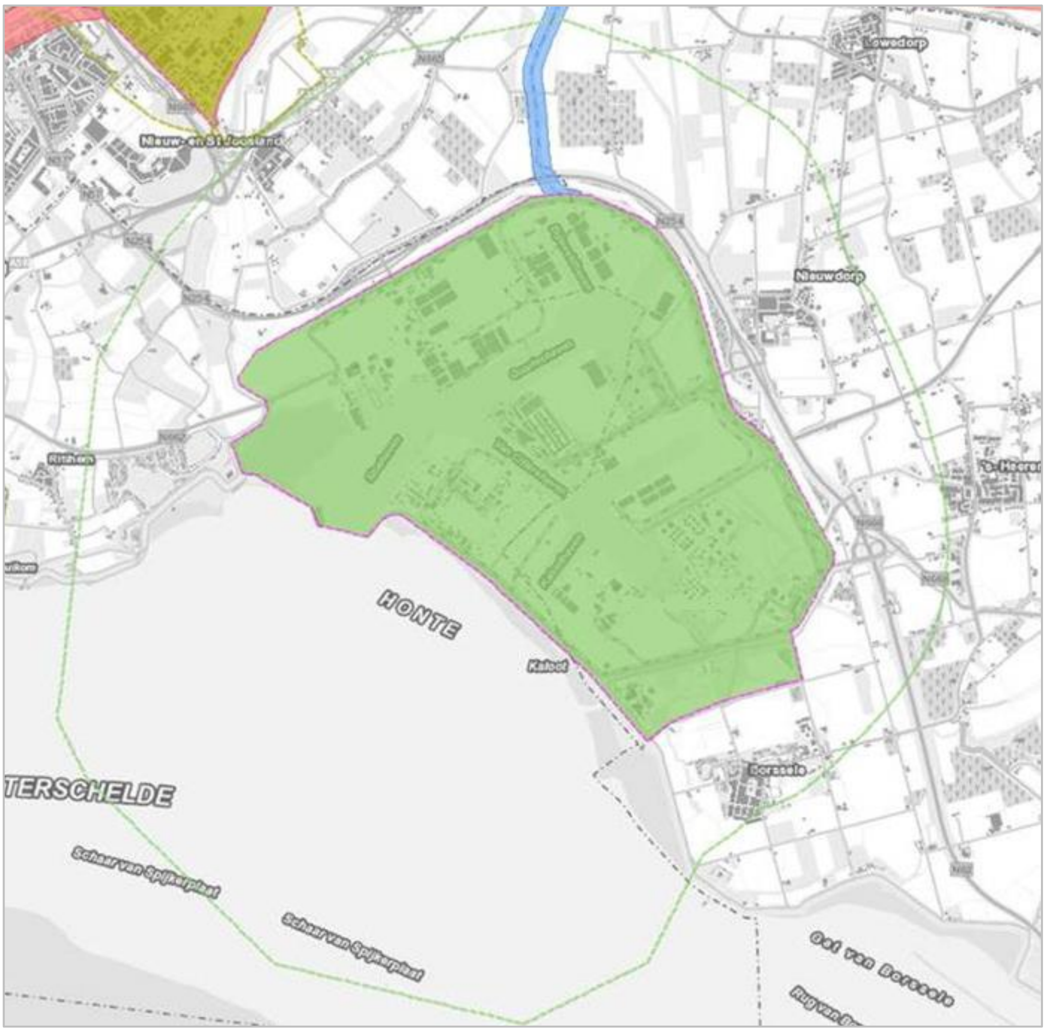

Figure 12-1 Zone boundary (green line) of Vlissingen-Oost industrial estate

In principle, the nuclear power plant operates 24 hours a day. Unless there are malfunctions, this is only deviated from for the annual fuel change.

Noise emissions from the power plant are mainly determined by sound radiation from the machine hall via ventilation grilles and glass façades, ventilators and outlet ducts on the roof of the machine hall, steam pipes, the AT transformer, the cooling water pump building and the cooling equipment on the roof of the office building. The number of transport movements on the site of nuclear power plant is extremely limited. On working days between 7 am and 7 pm, this averages nine vehicles, which are mainly delivery vans and the odd lorry. Outside these times, the average is two vehicles per month.

The emergency power generators at the site are tested for one to two hours every four or eight weeks. These tests are generally carried out on normal working days. Except for the occasional operating situation mentioned below, never more than one emergency generator is tested on a single working day.

During the annual refuelling period, the nuclear power plant is out of service for maintenance and when changing the fuel elements. Most of the aforementioned noise sources are then switched off temporarily or completely. The commissioning and decommissioning of the plant may cause unusual levels of noise emission. The highest levels of noise emission occur when testing the switching on of the three emergency power generators. This is an ad hoc operation that in principle only occurs once a year.

12.4.2 Noise regulations for the current permit under the Nuclear Energy Act

The current permit under the Nuclear Energy Act is the revision permit dated 12 July 2016, which was last amended on 12 December 2022. When the permit was granted an assessment was carried out to establish whether the nuclear power plant could be accommodated in the zone and whether the limit values applicable to residences in the zone would be complied with. This took into account the contribution of noise from businesses at the industrial estate and the area levels set for plots of land that had not yet been built on. The limit values for the combined noise level were therefore taken into account when the permit was granted. The noise emission in dB(A) per square metre for the nuclear power plant was not mentioned in the preamble to the permit. However, given the noise zone test carried out by the zone manager, it can be assumed that the nuclear power plant complies with the area level of 64.5 dB(A)/m^2 during the day and evenings and 62.5 dB(A)/m^2 during the night as laid down in the '2014 acoustic development plan for Vlissingen-Oost industrial estate', accompanying the '2008 policy regulation for the zone management system at the Vlissingen-Oost industrial estate, Province of Zeeland'.

The noise regulations in the 2016 revision permit are summarised in this section.

The long-term average assessment level ($L_{Ar,LT}$) caused by the Borssele nuclear power plant is not permitted to be higher than levels referred to in Figure 12-2 for the points given in Table 12-3.

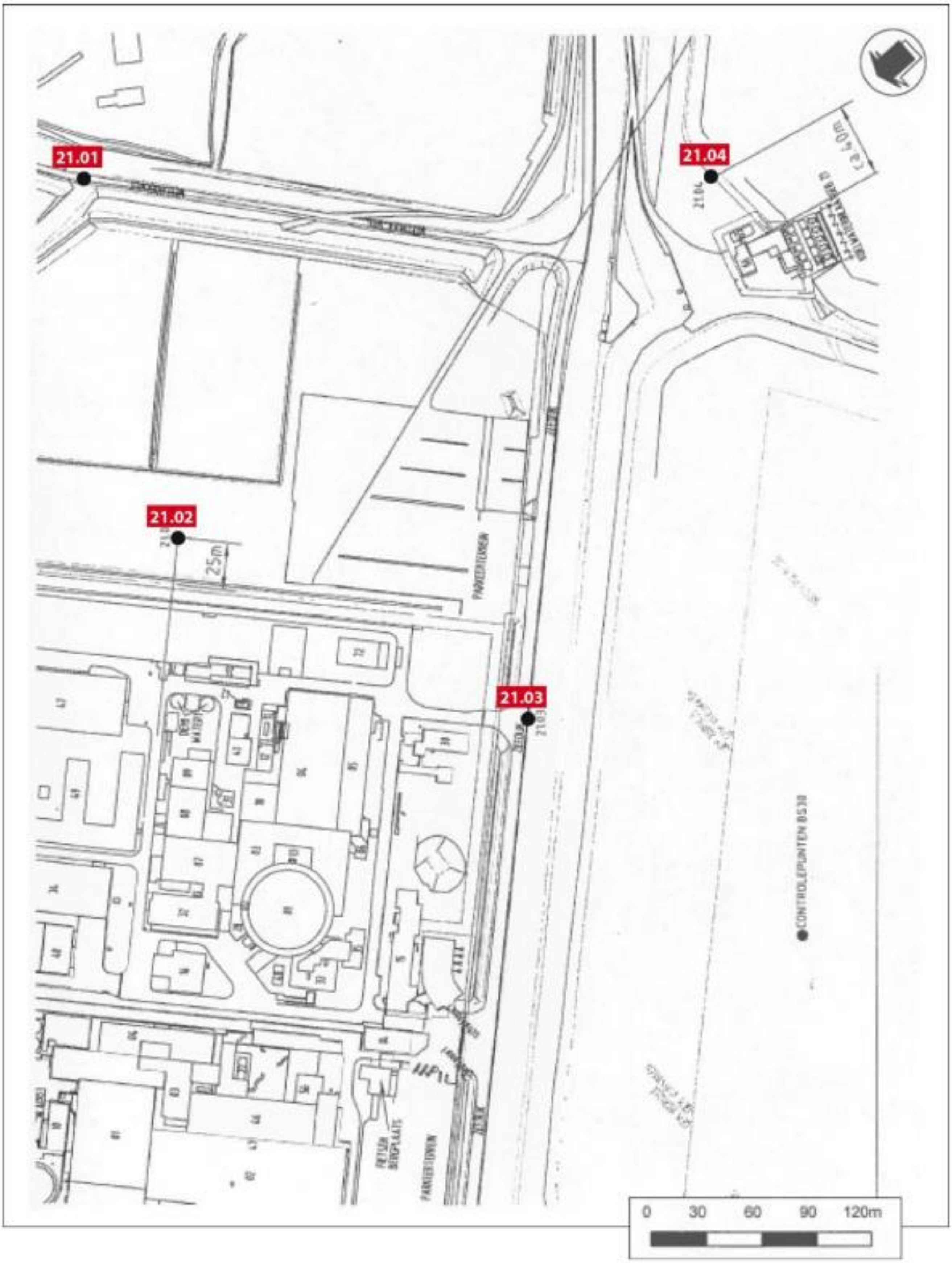

Figure 12-2 Measurement points for noise according to the 12 July 2016 revision permit

Table 12-3 Noise regulation for long-term average assessment level $L_{Ar,LT}$

Measurement point	Long-term average assessment level $L_{Ar,LT}$ in dB(A)		
	Daytime 7 am to 7 pm	Evenings 7 pm to 11 pm	Nighttime 11 pm to 7 am
Measurement point 21.01	44	44	44
Measurement point 21.02	56	56	56
Measurement point 21.03	62	62	62
Measurement point 21.04	60	60	60

For the regularly occurring anomalous operating conditions when the nuclear power plant is commissioned and decommissioned and test runs of the emergency generators, the long-term average assessment level (without an operating time correction) is not permitted to exceed the aforementioned levels plus 8 dB(A).

The maximum noise level of L_{Amax} due to peak noise is not permitted to be higher by more than 10 dB(A) at the measurement points than the levels for long-term average assessment level given in Table 12-3. This does not apply to loading and unloading operations, including delivery and removal work, and maintenance of buildings and infrastructure to the extent that this work is carried out between 7 am and 7 pm.

Every five years, noise levels must be measured at the various measurement points shown in Figure 12-2 to check compliance with the stipulated criteria for noise.

12.4.3 Noise levels at Borssele nuclear power plant

Every five years, noise measurements at the aforementioned measurement points ascertain whether the nuclear power plant meets the noise levels under the permit. During the previous ten years, measurements were taken in 2015, 2016 and 2021. Noise calculations were also made in the interim in 2017, based on an updated calculation model for the nuclear power plant and the industrial estate. The assumptions and results of these measurements and calculations are recorded in the following reports:

- Noise measurements September 2015:
  'Nalevingscontrole vergunningvoorschriften met betrekking tot geluid Kernenergiecentrale Borssele (BS-30)' (i.e. 'Compliance monitoring of permit requirements related to noise Borssele nuclear power plant'), Peutz report number FJ 1883-1-RA dated 28 September 2015.
- Noise measurements October 2016:
  'N.V. EPZ Borssele nuclear power plant (BS-30). Nalevingscontrole geluidvoorschriften in Kew-vergunning; Status-quo: oktober 2016' (i.e. 'Compliance monitoring of noise regulations for the permit under the Nuclear Energy Act; Status quo: October 2016'), Peutz report number FK 1883-1-RA-001 dated 8 December 2016.
- Noise calculations January 2017:
  'N.V. EPZ Borssele nuclear power plant (BS-30). Akoestisch onderzoek' (i.e. 'Acoustic research'), Peutz report number FK 1883-2-RA dated 7 February 2017.
- Noise measurements September 2021:
  'Nalevingscontrole van geluidvoorschriften in Kew-vergunning, Kernenergiecentrale Borssele (BS30)' (i.e. 'Compliance monitoring of noise regulations for the permit under the Nuclear Energy Act, Borssele nuclear power plant'), Peutz report number FK 1883-2-RA dated 8 November 2021.

The results of the aforementioned measurements and calculations are summarised in Table 12-4. Based on this, noise levels at several measurement points have increased to a degree since 2015. However, it should be noted that the 2021 report stated that the results of the measurements were affected by a very strong, sustained wind. As a result, the noise level measured was determined not only by the nuclear power plant, but also by the noise of wind in the trees and wind noise in the microphone. The report shows that the noise level measured was mainly due to wind in the trees situated there, particular at measurement points 21.01 and 21.02. At measurement point 21.01, the noise level measured was also emitted by the TenneT 380-kV high-voltage substation. Based on previously measured relationships between the noise level at measurement points 21.01 and 21.02, the 2021 report concludes that it is safe to assume that the noise level due to the nuclear power plant alone at measurement point 21.01 is well below 43 dB(A). The noise levels calculated for the nuclear power plant in 2017 correspond well with the noise levels measured in 2021, given the interference noise in the surroundings.

Taking into account the aforementioned remarks, the conclusion based on the studies cited above is that Borssele nuclear power plant is well within the prevailing noise regulation requirements.

Monitoring point 21.01 is located on the Weelhoekweg, about 40 metres away from the residential property closest to the nuclear power plant. This means that the long-term average assessment level due to the nuclear power plant where the residence is located is not more than 44 dB(A) during the day, evening and night. This house is situated within the noise zone of the Vlissingen-Oost industrial estate.

Table 12-4 Measured, calculated and permitted long-term average assessment level $L_{Ar,LT}$ at Borssele nuclear power plant

Measurement point	Long-term average assessment level $L_{Ar,LT}$ (dB(A)) during the day, evening and night				
	Noise measurements September 2015	Noise measurements October 2016	Calculated January 2017	Noise measurements September 2021	Under the permit
Measurement point 21.01	44 to 45	42	44.0	51 to 52 (<43)*	44
Measurement point 21.02	50	49	52.5	55**	56
Measurement point 21.03	50	48	54.8	54	62
Measurement point 21.04	52	52	54.5	56	60

** At measurement point 21.01, the noise level measured was mainly due to wind noise in the trees located there and due to the TenneT 380-kV high-voltage substation. Based on previously measured relationships between the noise level at measurement points 21.01 and 21.02, the 2021 report concludes that it is safe to assume that the noise level due to the nuclear power plant alone at measurement point 21.01 is well below 43 dB(A).*
*** At measurement point 21.02, the noise level measured was mainly due to wind noise in the trees located there.*

12.4.4 Transboundary effects

No transboundary effects are expected from the noise at the Borssele nuclear power plant. The noise meets the limits set for the local area and its range is limited, with noise effects therefore unlikely to occur beyond the national border.

12.5 Extrapolation of the environmental situation

12.5.1 Anticipated developments

Several other energy projects are under development in the immediate vicinity of the Borssele nuclear power plant. These projects include the converter station for the IJmuiden Ver Alpha offshore grid, the converter station for the Nederwiek 1 offshore grid and the 380 kV high-voltage substation near the Sloegebied.

A noise zone has been established around the Vlissingen-Oost industrial estate, setting a limit to the combined noise level of all establishments currently based and based in the future at the industrial estate. To ensure that all plots at the industrial estate can be used for operations in the designated environmental categories, a policy regulation has been adopted to manage the available noise zone at the industrial estate. This is the '2008 policy regulation for the zone management system at the Vlissingen-Oost industrial estate, Province of Zeeland'. As part of the policy regulation, the Provincial Executive of Zeeland adopted the '2014 acoustic development plan for Vlissingen-Oost industrial estate' on 9 December 2014. This zoning plan regulates the actual layout of the noise zone at the industrial estate. To this end, the industrial estate has been divided into several areas. Each area has its own particular level, known as an area level, in the noise zone. This means that the entire Vlissingen-Oost industrial estate can be occupied, while at the same time respecting a combined noise level of no more than a 24-hour average level of 50 dB(A) at the zone boundary. Because a noise allocation 'budget' – the area level – has been set for each plot on the industrial estate, and all developments on the industrial estate are obliged to respect the area levels, they will not (significantly) influence each other's development, and the combined noise levels will respect the established noise zone and limit values at residential properties in the zone.

12.5.2 Extrapolation

The expectation is that operating the Borssele nuclear power plant after 2023 will have none or hardly any consequences for the environmental aspect of noise. It is not clear whether existing noise sources will change or new noise-producing systems will be introduced due to extending the operating life of the nuclear power plant. However, if this were to happen, the nuclear power plant will have to observe the area level established for the plot in question. In addition, the combined noise from the nuclear power plant and the rest of the industrial estate will have to observe the established noise zone and limit values at residential properties in the zone.

Any modifications to the power plant due to extending the operating term may also affect the noise level at noise-sensitive buildings during the construction phase. Nothing is known about this as it stands now. However, the noise standards under the Dutch Structures (Living Environment) Decree [*Besluit bouwwerken leefomgeving*] will presumably be met if there is any construction work. This will, however, require further investigation in the future.

12.6 Outlook for EIA Phase 2

During EIA Phase 2, it will be clear whether any technical adjustments to the nuclear power plant are necessary. An assessment will have to be carried out at that time to establish whether this will have relevant impacts on the surrounding area and the noise zone.

This assessment will have to focus on the operating phase as well as on construction work, if applicable. Any problem areas and/or knowledge gaps will be identified and an agenda of environmental focal points for the follow-up will be drawn up.

Any changes in noise limits must also be taken into account. Currently, the levels set out in the former Noise Abatement Act still apply, but this assessment framework may change in the future in the wake of the Environment and Planning Act and the drafting of a comprehensive environmental plan.

12.6.1 Key environmental focal points

An area value of 64.5 dB(A)/m^2 during the day and evening and 62.5 dB(A)/m2 during the night have been set for the plot on which the nuclear power plant is situated in the ‘2014 acoustic development plan for Vlissingen-Oost industrial estate’. Based on the acoustic development plan, the entire Vlissingen-Oost industrial estate can be occupied, while at the same time respecting a combined noise level of no more than a 24-hour average level of 50 dB(A) at the zone boundary. The main environmental concern for the operating phase is the assessment of the area level and the integration into the noise zone.

13 Environmental focal points

The final section of this EIA includes an overview of the exploration that has taken shape in the previous chapters. The following points are highlighted for each aspect in the sections below:

- An extrapolation in broad outlines for the period following 2033.
- An agenda listing environmental focal points (not exhaustive) for the follow-up phase.

13.1 In general

This EIA outlines the current situation at KCB. Operations, such as cooling water intake and discharge, contamination and nitrogen deposition, have the potential to put pressure on the environment. The various aspects must be reconsidered in EIA Phase 2. Based on the results of EIA Phase 1, it can be concluded there are no direct obstacles to the proposed legislative amendment beforehand. In Phase 2 of the EIA, all environmental impacts must be reconsidered and assessed again, for the purpose of the permit application for the intended extension of the operational lifespan itself.

As set out in Section 1.2.2, this EIA Phase 1 does not include a detailed analysis of KCB's existing rights. However, it is important to determine before EIA Phase 2 to what extent there are existing rights after 2033, and after amending Section 15a of the Nuclear Energy Act. Existing rights have to be identified based on the outcome of ongoing technical feasibility studies and the way the KCB will continue to operate.

There are several energy projects in progress in the vicinity of KCB, which are under the auspices of the government. This EIA includes a description of the cumulative effects of KCB and its environs. The potential extension of KCB's operating life can be accommodated as part of industrial developments, provided measures are taken to solve local problem areas in the high-voltage grid.[50] At the time of writing EIA Phase 1, the Ministry of Economic Affairs and Climate Policy was also working to increase the number of its stakeholder managers in the Borssele region, and exploratory discussions are taking place on how all current and future projects can be considered in conjunction with one another. Approaching these projects in this way will have to be considered in EIA Phase 2.

Table 13-1 outlines the points of attention for Phase 2 per sub-aspect.

Table 13-1 Points of attention for Phase 2 per sub-aspect

Sub-aspect	Requires attention
Nature	Requires significant attention, specifically species and area protection.
Radiation protection	Requires attention, must be in compliance with laws and regulations in all cases.
Nuclear safety	Requires attention, must be in compliance with laws and regulations in all cases.
Water	Requires attention, specifically water quality (in relation to sub-aspect Nature).
Health and safety	Requires attention, must be in compliance with laws and regulations in all cases.
Soil	Requires no additional attention, must be in compliance with laws and regulations in all cases.
Noise	Requires no additional attention, must be in compliance with laws and regulations in all cases.

13.2 The natural environment

Ecosystems are complex. Changes are constantly taking place, among other things as a result of abiotic variations and human influence. Several factors will bring about changes in the future ecological status of KCB. Clear positive or

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[50] An investigation of incorporating the new Borssele and Maasvlakte nuclear power plants in the grid (tennet.eu) (article in Dutch)

negative trends for biotic communities in the future can therefore not be predicted with any degree of certainty. The basic assumption made is that both negative and positive factors play a role, and that the situation of the biotic communities will continue in the same manner. For most biotic communities, the situation will therefore continue to fluctuate. Only for marine mammals will the (extrapolated) situation remain predominantly positive, although the accumulation of contaminants does continue to represent an issue requiring attention.

Several KCB operations, especially cooling water extraction and discharge, contamination and nitrogen deposition, potentially exert relatively high pressure on the ecosystem. This emphasises the need for a more detailed ecological assessment in EIA Phase 2. **Nitrogen deposition** is a criterion that requires further investigation for EIA Phase 2, for the aspect of ecology. Any knock-on effects on animals are also relevant. **Extraction and discharge of cooling water** are environmental impacts that require further investigation for EIA Phase 2, for the aspect of ecology. **Pollution** in general is an issue requiring attention for EIA Phase 2 with regard to ecology. In particular for marine mammals; they are very susceptible to the accumulation of pollutants.

A further assessment will be necessary within the framework of Natura 2000, Water Framework Directive, Flora and Fauna and Nature Network Zeeland. This will be part of EIA Phase 2. In the process, an important (legal) aspect is KCB's existing rights. It may have a major impact on the required content of the ecological assessments in EIA Phase 2. Mitigation measures can be explored and put forward in EIA Phase 2, if necessary. These are measures that could compensate for or ameliorate significant negative impacts.

13.3 Radiation protection during regular operations

If the Borssele nuclear power plant continues to operate after 2033, it is expected that, in a similar way to now, all legal requirements regarding radiation protection, including those concerning emissions into the air and water, will continue to be met.

When planning to build new nuclear power plants, it is up to those advocating for them to demonstrate that their impact on the Borssele nuclear power plant's nuclear safety will be sufficiently low.

No bottlenecks and/or knowledge gaps have been identified as environmental focal points for EIA Phase 2 with regard to the operating period after 2033 for the aspect of radiation protection.

13.4 Nuclear safety

KCB meets the legal criteria in terms of controlling design basis accidents and their potential radiological consequences. It also meets the risk criteria for individual and group risks for beyond design basis accidents. The safety analyses underpinning this will have to be renewed for operations after 2033, based on the regulations and guidelines in force at the time.

Climate change impacts seawater and air temperatures, sea level rise, and extreme weather events. For the current situation, it has been demonstrated that KCB's cooling systems can provide sufficient cooling at the maximum possible water temperature, even in accident situations. It has also been demonstrated for the current situation that KCB is adequately protected from seawater and flooding. For a longer operating life beyond 2033, these aspects will have to be demonstrated for the then assumed maximum possible water temperature and maximum seawater levels.

When planning to build new nuclear power plants, it is up to those advocating for them to demonstrate that their impact on the Borssele nuclear power plant's nuclear safety will be sufficiently low.

Before KCB can continue operating beyond 2033, all systems, structures and components with a nuclear safety function must be demonstrated to be available and reliable for the anticipated period of operation. This will be done under the auspices of ANVS as the supervisory authority and based on technical investigations, safety studies in accordance with the legislation, regulations and guidelines applicable at the time.

The above extrapolation leads to the following environmental focal points for EIA Phase 2 regarding the operating period beyond 2033:
- Updating the safety analyses for the purpose of testing the control of design accidents and their possible radiological consequences, and the risk criteria for the individual and group risk for off-design accidents.
- Updating the assessment of any transboundary effects of accidents.

- Demonstrating that the safety-relevant cooling systems, even in accident situations, can sufficiently cool Western Scheldt water at the maximum possible water temperature to ensure nuclear safety.
- Demonstrating that air cooling in safety-relevant buildings, including in accident situations, can provide sufficient cooling at the maximum possible air temperature to ensure nuclear safety.
- Demonstrating that adequate protection of KCB is in place against the maximum seawater levels to be assumed to ensure nuclear safety.
- Demonstrating that adequate protection of KCB is in place against the maximum wind speeds to be assumed to ensure nuclear safety.
- Demonstrating that the effects of ageing of systems, components and structures with a nuclear safety function are controlled for the intended operating life extension.
- Demonstrating that in addition to the technical aspects of ageing, the organisational, procedural and administrative aspects have also been dealt with adequately in the LTO programme.

13.5 Water

Due to climate change, sea levels are rising and precipitation is less predictable, with drier summers and wetter winters (extreme weather conditions). These changes may affect operations at the Borssele nuclear power plant. It may become more difficult to use seawater from the Western Scheldt for cooling because of rising water temperatures. This may result in the permitted water extraction being limited. In addition, discharging water from the cooling water system may also become problematic since it leads to the discharge of more heat into water that is already warm.

Due to climate change, we are having warmer, drier summers more frequently. This is causing drought and a drop in surface and groundwater availability,which impacts water quality as well as water quantity in a negative way. Any future restrictions regarding the extraction of saline and other groundwater may affect the availability of the emergency cooling water system of the nuclear power plant. Climate change may also have a negative effect on recreation, particularly because of the effect on water quality. Concentrations of (chemical) substances in the water increase during droughts and periods of low discharge. This affects the bathing water quality of the swimming site, the Kaloot, immediately west of KCB.

Water quality is the main environmental concern for water as an environmental aspect. A water emission test for any future granting of a permit will provide detailed insight into the effects of the cooling water discharge on the water quality of the Western Scheldt. In addition, modelling of the heat plume and discharge plume is needed to gain a better understanding of the extent of cooling water discharge effects.

13.6 Health and safety

No changes are to be expected in the effects of conventional aspects if operations continue as they are. There are no environmental focal points for EIA Phase 2.

13.7 Soil

The protection of the soil quality is provided for in the legislation and regulations in force. EPZ complies with the measures and provisions laid down in the permits issued. As a result, activities that may be detrimental to the soil will have no consequences. The soil quality is therefore not expected to deteriorate in the future. There is a duty of care should incidents or activities that may be detrimental to the soil demonstrably cause soil contamination. Soil contamination that arises after 2023 must be remediated. There are no environmental focal points for EIA Phase 2.

13.8 Noise

The expectation is that operating the Borssele nuclear power plant after 2023 will have none or hardly any consequences for the environmental aspect of noise. It is not clear whether existing noise sources will change or new noise-producing systems will be introduced due to extending the operating life of the nuclear power plant. If this were to happen, the nuclear power plant will have to observe the area level established for the plot in question. In addition, the combined noise from the nuclear power plant and the rest of the industrial estate will have to observe the established noise zone and limit values at residential properties in the zone. The main environmental concern for the operating phase is the assessment of the area level and the integration into the noise zone.

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Annex 1 Explanatory Memorandum

Annex 2 Assumptions for the AERIUS calculation for the Borssele nuclear power plant

Annex 3 AERIUS calculation for the Borssele nuclear power plant

Annex 4 Soil survey report

Annex 5 Summary of the soil dossier

Colophon

ENVIRONMENTAL IMPACT ASSESSMENT
AMENDMENT OF THE NUCLEAR ENERGY ACT

CLIENT
Ministry of Economic Affairs and Climate Policy

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