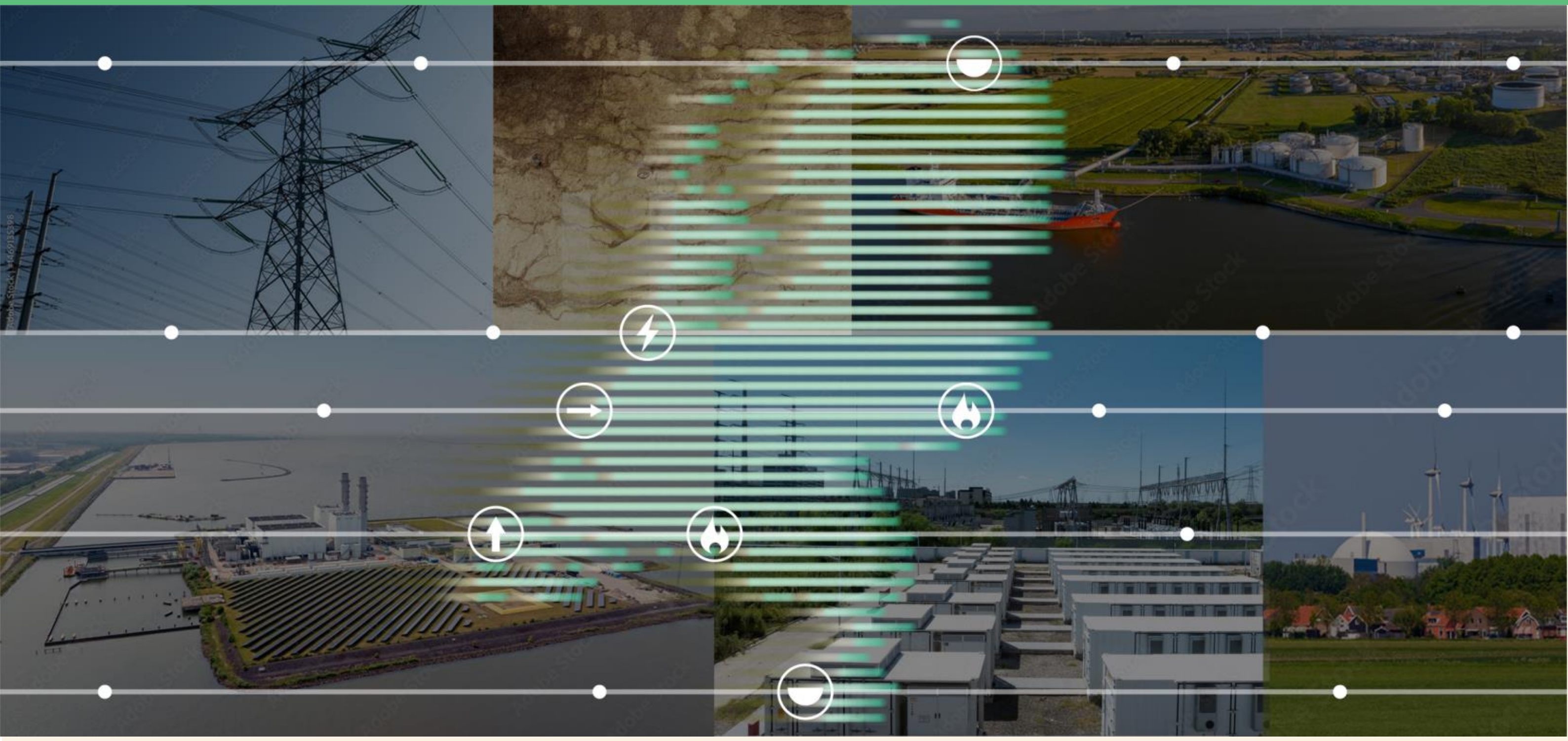

REPORT

Draft Memorandum on Scope and Level of Detail

National Energy Network Development Plan IIA/SEA-r

Commissioned by: Ministry of Climate Policy and Green Growth

Reference: BK4888-HAS-XX-XX-RP-X-0001

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Ministerie van Klimaat en Groene Groei

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Contents

Structure of this document

This is the draft Memorandum on Scope and Level of Detail (draft NRD) of the National Energy Network Development Plan (PEH) II. Chapter 1 provides a general explanation of the programme, the place of this draft NRD in the Environmental Impact Assessment (EIA) procedure and the policy context within which this programme is being made. In Chapter 2, the nature of a programme, the procedure and the steps to be completed in an Integrated Impact Analysis/Strategic Environmental Assessment report (IIA/SEA-r) and the participation process are elucidated. Chapter 3 explains the development of alternatives and Chapter 4 discusses the working method followed for the impact assessment in the IIA/SEA-r. The participation plan has been included as an appendix. The most important terms used are shown below.

Table 0-1 Most important terms used

Terms	Explanation
AC	Alternating Current. The regular (overhead) high-voltage network uses alternating current.
Development of alternatives	Overarching process of developing variants of the base scenarios, solution pathways and translating them to robust developments and strategic choices.
Base scenario	Scenarios developed by Netbeheer Nederland in 2025 that provide the basis for developing the alternatives for the Integrated Impact Analysis.
DC	Direct Current. The underground 2GW landfall sites use direct current.
Flexibility/flexible sources	Means of creating equilibrium between supply and demand for electricity, such as energy storage, demand management or conversion to a different energy carrier.
Bottleneck	Exceedance of available capacity of energy infrastructure for which a solution is required, as revealed by the network calculations performed by the grid operators.
Robust bottleneck or development	Bottleneck or development in the energy infrastructure that occurs in (nearly) all base scenarios and variants.
Solution pathway for energy infrastructure bottleneck	Possible solution to a bottleneck in the energy infrastructure, for example grid reinforcement.
(Scenario) variant	Energetic or spatial variation on the base scenarios.
Strategic choice	Choice about the long-term configuration of the energy system. In National Energy Network Development Plan I, the term ‘structural choice’ was used to denote this.
Sample year	Target year considered in a specific analysis in order to work out the development pathway for a scenario or variant in more detail.
Acceleration area	As referred to and described in the Renewable Energy Directive (RED) III as Renewable Acceleration Area (RAA). RED III introduces the possibility of designating acceleration areas for renewable energy projects and adjacent infrastructure.

1 Introduction

1.1 Background and scope of National Energy Network Development Plan II

The energy transition is essential in order to make the Netherlands more resilient, climate neutral and energy independent in the future. The transition calls for far-reaching modifications to the infrastructure of our energy system, both above and below ground. The goal of the National Energy Network Development Plan (PEH) is to provide sufficient space for the national energy network in this transition to 2050. Every four years, the PEH is reviewed in order to adjust the programme where necessary, based on new insights, and to be able to respond to new spatial planning issues. What is understood by the national energy network in the context of the PEH is visualised in the image below and represented in the table that follows.

Modifications to the national energy network call for a consideration of interests or policy objectives. To this end, the impacts of different choices in the energy mix and different choices in the spatial planning of energy functions are identified. The impacts in question are those on environment & space, energy system, cost and feasibility. With this in mind, an Integrated Impact Analysis (IIA) and a Strategic Environmental Assessment report (SEA-r) are drawn up.

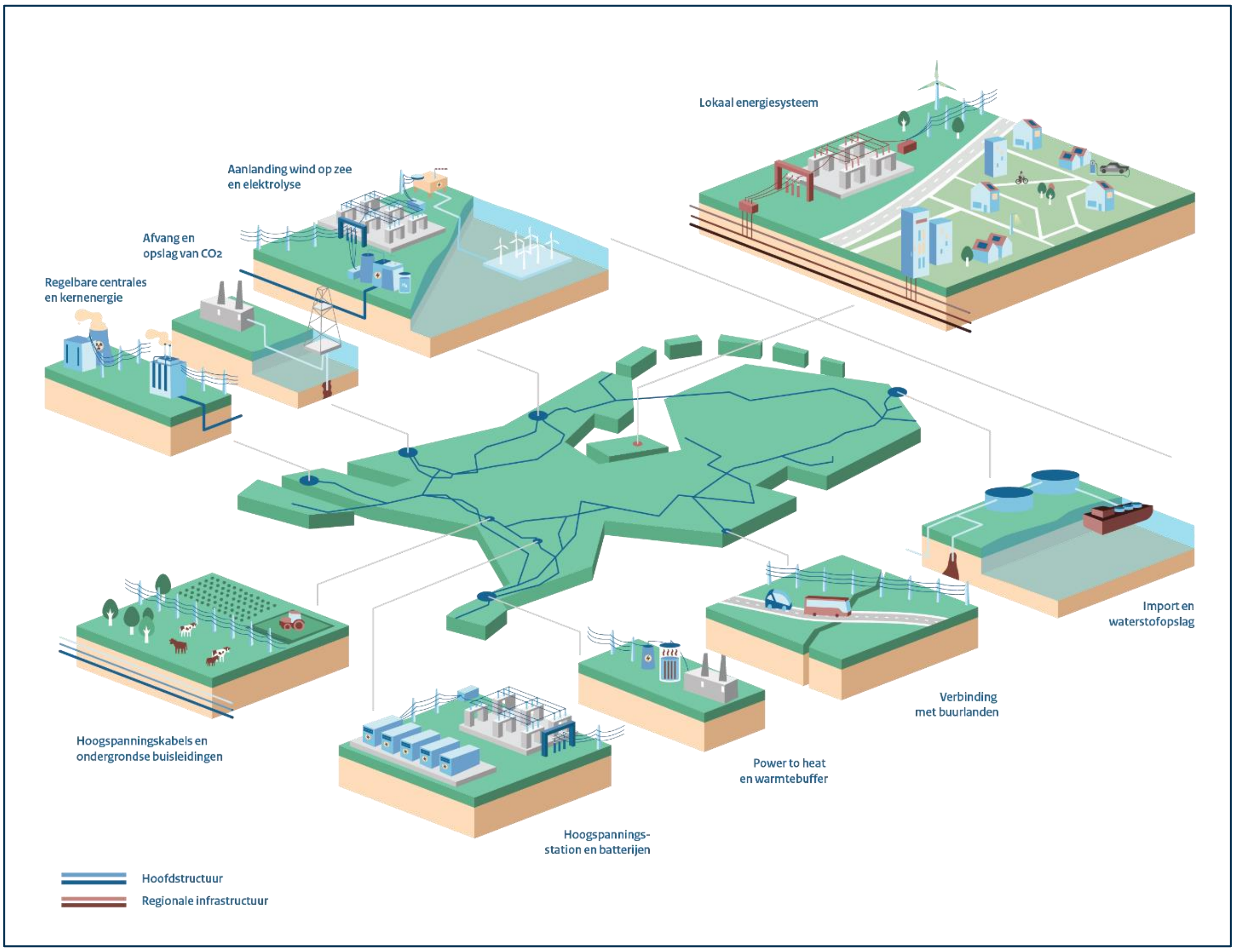


Figure 1-1 Visualisation of scope of the National Energy Network Development Plan

Table 1-1 Scope of National Energy Network Development Plan II – on land (unless specified otherwise)

Component of the national energy network	Description
High-voltage power lines from 110 kV upwards	Overground 220/380kV power lines and 220/380kV substations, including coupling transformers between 380kV and 110/150 kV.[1] This also includes interconnection: connections between the Dutch power grid and foreign power grids.
Large-scale power stations (excluding nuclear energy)	Power stations running on, for example, hydrogen (or hydrogen derivatives) and/or methane (green gas or natural gas) with a capacity greater than 500 MW.
Large-scale system batteries	Batteries with their own network connection and a capacity greater than 100 MW.
Large-scale electrolysis	Electrolysers with a capacity greater than 100 MW.
Pipelines of national importance	Pipelines for long-distance transport of gaseous or liquid energy carriers and other (raw) materials, such as hydrogen, methane (green gas and/or natural gas) and ammonia, including connections to other countries.[2]
Underground storage for hydrogen	Large-scale underground storage for hydrogen, in salt caverns and potentially in empty gas fields and/or storage facilities on land. Determined on the basis of the Sustainable Use of the Deep Underground Programme.
Additional components of PEH II compared to PEH I	
Locations for deep landfall sites	2GW underground electrical direct current power lines for further landward transmission (beyond the coastal provinces) of offshore wind energy. Determined on the basis of the Preliminary Study into Deep Landfall Sites for Offshore Wind Energy.[34] These power lines can also be used as hybrid interconnectors with neighbouring countries.[5]
DC[6] hubs	Substation between two (or more) DC power lines, where direct current power lines meet and/or they connect with the AC network.[7] Considered in combination with deep electrical landfall sites. Determined on the basis of the Preliminary Study into Deep Landfall Sites for Offshore Wind Energy.
Coastal locations of offshore wind landfall sites	2GW subsurface electrical direct current connections for offshore wind energy in the coastal provinces. Coordinated with the Exploration of Offshore Wind Energy Landing (VAWOZ) programme. See footnote 2 for a description of components. These power lines can also be used as hybrid interconnectors with neighbouring countries (see footnote 5).
Supplementary nuclear energy preference areas	Areas for possible development of large nuclear power plants and Small Modular Reactors (SMRs).

[1] "The design principles will be updated where necessary for high-voltage power lines from 110kV."
[2] Based on areas defined by municipalities. Definition of pipelines of national importance, as defined in the Living Environment (Quality) Decree: pipelines which are part of a network of pipelines that run across provincial boundaries which is designed or used for long-distance transport of hazardous substances, including hydrogen, methane, ammonia and carbon dioxide.
[3] The Preliminary Study into Deep Landfall Sites for Offshore Wind Energy involves investigating reasonable alternatives for routes and locations. Following evaluation, these will be included in PEH II. A power line consists of a subsea/subsurface cable to a converter station and a subsurface alternating current cable connecting it to a 380KV substation.
[4] An overhead DC network is also briefly considered under the 'Well-being' theme.
[5] A hybrid interconnector has a dual function: connecting the power grids of the two countries and directly connecting offshore wind farms with land.
[6] Direct Current. The regular (overhead) high-voltage network uses alternating current (AC).
[7] TenneT has indicated that these hubs can potentially add value to the electricity system in combination with the deep landfall sites.

Component of the national energy network	Description
Fuel import terminals	Terminals for importing sustainable fuels such as hydrogen and ammonia.
CO_2 capture, transport and storage	Space for storage at sea, pipelines and other infrastructure on land (for example, for transport by ship) for transporting CO_2 from its capture within a commercial facility towards storage at sea.[8]
Heat infrastructure	Locations for the development of supraregional heat networks and spatial impact of power-to-heat (conversion of electricity to heat and heat storage).

The Renewable Energy Directive III (REDIII) introduces the possibility of designating acceleration areas for renewable energy projects and adjacent infrastructure. A further goal of the IIA/SEA-r for PEH II is to investigate whether potential acceleration areas (pilots) can be designated for energy infrastructure.

1.2 Objective of this draft Memorandum on Scope and Level of Detail

The objective of this draft Memorandum on Scope and Level of Detail (draft NRD) is to inform all parties about the scope of the National Energy Network Development Plan II (PEH II) and to indicate which aspects will be investigated in the IIA/SEA-r. An NRD describes the delineation and approach of the research that will be carried out in the IIA/SEA-r. For this reason, the NRD sets out which alternatives will be developed ('scope') and which aspects will be used to evaluate them ('level of detail'). The research in the IIA/SEA-r is based on the following themes: 1) Energy system efficiency, 2) Environment & space (SEA-r), 3) Well-being and 4) Feasibility. These themes are detailed in the assessment framework in Chapter 4.

The ministries of Climate Policy and Green Growth, Housing and Spatial Planning and Infrastructure and Water Management want to actively involve citizens, civil society organisations and other administrative bodies in the establishment of PEH II. For this reason, a participation process has been set up in order to enable stakeholders to participate in various ways. The participation process is explained in more detail in section 2.4 and the participation plan is attached to this document as an appendix.

The draft NRD is first presented for inspection so that all parties have the opportunity to respond. Section 0 of this draft NRD specifies how participation has taken place and can take place. It also discusses the presentation of the document for public inspection and opportunities to respond. The research agenda for the IIA/SEA-r is finalised in the actual NRD.

1.3 Relationship with other programmes and pathways

PEH II is connected with various other programmes and pathways. The most important programmes and pathways that are closely connected with the task of PEH II are explained below.

National Spatial Strategy
The National Spatial Strategy is the overarching national vison of the living environment. The draft National Spatial Strategy translates the challenges for the Netherlands towards 2050 in planning terms and looks ahead to 2100. It is concerned with major national challenges such as water and soil, housing, economy, defence, heritage, agriculture and nature. The National Spatial Strategy provides the basis for further elaboration of policy through other instruments (such as PEH).

[8] *The routes for pipelines at sea fall outside the scope of PEH II.*

In the draft National Spatial Strategy, the national energy system is a crucial element of spatial planning in the Netherlands. The aim is to reduce dependence on energy from other countries. More energy will therefore be generated in the Netherlands. Anticipated developments include more offshore wind energy, onshore wind and solar energy, hydrogen, green gas, nuclear power plants and heat sources. A sustainable energy system requires more space than a fossil-based system. The transition to a sustainable energy system will, temporarily, also require additional space for the conversion of the system, with a low-carbon system existing simultaneously with a fossil system. PEH II looks ahead to a future climate neutral energy system and considers the associated space requirements.

National Energy System Plan (NPE)
The National Energy System Plan (NPE) is a long-term vision of the energy system in 2050. The plan sets out developmental trajectories and makes key strategic decisions for the development of the energy system. The NPE is updated every five years, and an additional interim update will take place in 2026. The basic assumptions for the NPE also underlie PEH II. For example, they are applied in the scenarios used for PEH II.

VAWOZ and PAWOZ-Eemshaven programmes and preliminary study for deep landfall sites
The Exploration of Offshore Wind Energy Landing (VAWOZ) and Offshore Wind Energy Connection (PAWOZ) Eemshaven programmes are concerned with investigating options for future cable and pipeline routes for wind farms in the North Sea to land. PAWOZ-Eemshaven explored connections for wind farms leading up to 2032 and for the wind farms that can connect in Eemshaven subsequently. VAWOZ is looking at the connection of wind farms beyond the 21GW Roadmap for the whole of the Netherlands. In addition, a preliminary study is also being conducted into landing offshore wind in the interior of the country, also known as deep electrical landfall sites. The results of this preliminary study will be included in PEH II.

Sustainable Use of the Deep Underground Programme and National Underground Hydrogen Storage Agenda
Underground hydrogen storage is very important for the hydrogen chain and will play a systemic role in the future energy system. The Sustainable Use of the Deep Underground Programme is working towards a vision and clear framework for future activities in the deep underground. The National Agenda is focused on the role and significance of underground hydrogen storage. The agenda also describes which steps are needed to create sufficient underground hydrogen storage in time.

Areas of overlap with other spatial challenges based on national sectoral spatial programmes
In order to identify the impacts of spatial planning choices relating to the national energy system, data and information are used from other sectoral national programmes and pathways, such as *Ruimte voor Defensie* (‘Space for Defence’), *Ruimte voor Landbouw en Natuur* (‘Space for Agriculture and Nature’) and *Ruimte voor Industrie* (‘Space for Industry’).

Regional programmes and pathways
PEH II is focused on infrastructure of national significance. In order to identify the optimal locations for this infrastructure, it is important to include in consideration local aims with regard to, for example, the economy or nature in the vicinity of proposed national energy infrastructure. Examples are the regional energy strategies (RES) and house-building plans at municipal and provincial level. It should be noted that PEH II does not affect the locations designated by municipal and provincial authorities for their wind turbines or house-building programmes.

2 Programme, EIA procedure and participation

2.1 Nature of the National Energy Network Development Plan II

A programme is a core instrument under the Environment and Planning Act which replaces structural visions. A core instrument such as a programme enables the authorities to create and implement policy. The programme provides a framework for decisions by the national government, such as project decisions. This means that the project decision must comply with the requirements laid down in the programme.

PEH II identifies the space requirements of the national energy system and associated anticipated developments of the energy infrastructure. It also formulates spatial policy aimed at steering particular developments towards the most suitable locations (preferred locations) – for example, by designating preference areas for particular developments. The Minister of Climate Policy and Green Growth is the competent authority for this programme and coordinates decisions with other ministries and public authorities. The Ministers of Housing and Spatial Planning and Infrastructure and Water Management are joint signatories.

As such, PEH II is the spatial planning framework for project decisions implemented by the national government. The elaboration of developments takes place in project procedures. In a project procedure, the siting is specified in more detail, further research is conducted and the licences required for construction are prepared. Once the project decision has taken effect, realisation can begin.

2.2 What is an IIA and what is an SEA-r?

2.2.1 Research in IIA/SEA-r

The potential impacts of components of the national energy network within the scope of PEH II are identified in order to be able to include them in the decision-making. Because PEH II is the framework for future project decisions, there is a requirement to perform an EIA (see the explanation in section 2.2.2). The Environmental Impact Assessment (EIA) is the procedure by which the environmental impacts of a plan are identified. The anticipated consequences are described in the Environmental Impact Assessment Report (EIA-r).

For this programme, alongside the environmental and spatial impacts of potential choices, it has been decided to take a broader perspective that includes impacts on energy system efficiency, well-being and feasibility. This means that an Integrated Impact Analysis (IIA) is being drawn up that will consider these themes. These themes are discussed in more detail in Chapter 4, IIA/SEA-r assessment methodology. The Environment & Space theme takes the form of a Strategic Environmental Assessment report (SEA-r). For this reason, the research conducted for PEH II is a combination of an IIA and an SEA-r.

2.2.2 When is there a requirement to perform an EIA?

Completing an SEA procedure is compulsory for a programme that provides a framework for decisions subject to the requirement to perform an EIA, such as the construction of a pipeline, high-voltage power line or electrolyser (section 16.4.1 of the Environment and Planning Act). For PEH II, this means there is a requirement to complete an SEA.

The legal basis for environmental impact assessment (EIA) is established in EU law. The European directive for strategic environmental assessment (SEA directive, EU directive 2001/42/EC[9]) regulates environmental impact assessment for plans and programmes, while EU directive 2011/92/EU is the EIA directive for projects. Dutch legislation on environmental impact assessment is contained in section 16.4 of the Environment and Planning Act and in Chapter 11 and Appendix V of the Environmental and Planning Decree. Section 11.3 of the Environmental and Planning Decree sets out the requirements for the content of the Strategic Environmental Assessment report (SEA-r). With the coming into force of the Environment and Planning Act, the substantive requirements of an Environmental Impact Assessment have not changed from those under the Environmental Management Act.

Elements of an SEA-r
The SEA-r must at least include the following elements:

- A description of the content and the reasonable alternatives, including reasons for the choice of those alternatives.
- The most important objectives of the programme.
- A description of the existing situation of the environment and its autonomous development if the programme is not implemented.
- All existing environmental problems that are relevant for the programme, particularly those in areas in which the protection of the environment plays an important role.
- A description of how relevant specified environmental objectives have been included in the programme.
- A description of the potential significant environmental impacts of the implementation of the programme.
- Measures to prevent, limit or compensate impacts, and monitoring.
- The gaps in knowledge.

2.3 Four phases to achieving the IIA/SEA-r for PEH II

In order to achieve an IIA/SEA-r for PEH II, four phases will be completed:

- **Phase 1: draw up Memorandum on Scope and Level of Detail (research approach)**
  The first phase is used to draw up a Memorandum on Scope and Level of Detail (research approach). The Memorandum on Scope and Level of Detail (NRD) describes the methodology, depth and scope of the research to be conducted for PEH II. The research approach proposes the scenarios and variants to be used and describes the methodology used to make strategic choices and identify robust bottlenecks. It also outlines the assessment framework that will be used to investigate these strategic choices and robust bottlenecks in the IIA/SEA-r.
- **Phase 2: analysis of bottlenecks via development of alternative scenarios**
  The development of alternatives that will be assessed in the IIA/SEA-r takes place in different steps. Firstly, scenarios and variants are drawn up that will help identify the required energy infrastructure and bottlenecks in the energy infrastructure. An energy system analysis is then carried out, resulting in an overview of the required components of the energy system for each scenario. Finally, based on the above, an assessment is made as to which components are essential in (nearly) all the scenarios and variants and which bottlenecks in the energy infrastructure occur in all of these scenarios and variants. These are robust bottlenecks or developments. Solution pathways are identified for the robust bottlenecks or developments. In addition, an evaluation is made of the impacts of the strategic choices on the energy system.
- **Phase 3: assessment of impacts**

[9] *The SEA directive defines environment as: "the biodiversity, population, health of humans, fauna, flora, soil, water, air, climate factors, material goods, cultural heritage, including architectonic and archaeological heritage, cultural landscape and the interaction between the above elements."*

This phase is focused on working out and investigating impacts of alternatives within the scenarios. This involves not only looking at impacts in terms of environment and space, but also at energy system efficiency, well-being and feasibility. This takes place in two research rounds: an exploratory study followed by an in-depth study.

- **Phase 4: conclusions**
  This phase is focused on formulating policy conclusions. The results of the studies into the different alternatives provide a picture of the possible consequences of different developments. Those results ultimately lead to a choice of developmental trajectories and the defining of prerequisites that are laid down in the programme. The conclusions are also aimed at creating prerequisites in order to implement projects more quickly.

2.4 Participation, consultation and advice

2.4.1 Participation plan

Participation is a important pillar of the Environment and Planning Act. The objective of the participation process for PEH II is, together with the public and local parties, to arrive at broadly supported solution pathways for different components of the national energy network.

The way in which civil society organisations, residents, companies and administrative bodies are involved in PEH II from an early stage is described in the participation plan (see appendix). This plan provides the basis for all participation activities throughout the duration of the National Energy Network Development Plan II and is updated in every phase. The figure below highlights the four important moments when participation takes place.

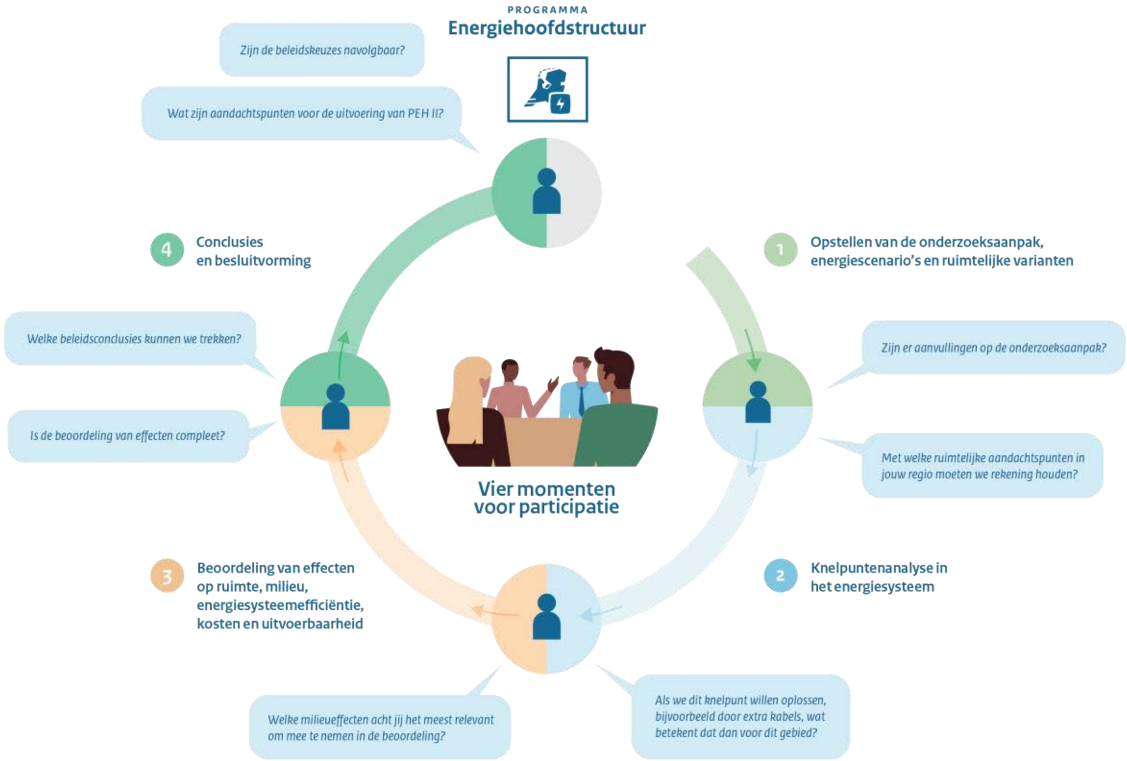


Figure 2-1 Four participation moments

2.4.2 Participation around the draft NRD

This draft NRD proposes promising solution pathways for investigation and the assessment framework that will be used to evaluate those solution pathways in the IIA/SEA-r. Various participation formats and activities have been employed to achieve this proposal.

After the draft NRD has been presented for inspection, anyone can submit a response as part of the formal consultation procedure which lasts 6 weeks (see section 2.4.3 for more details). During this period, webinars will be held in which the PEH II programme team will engage in dialogue with the wider public and interested parties. The aims of the information meetings include explaining the role of an NRD in the IIA/SEA-r process, what is being investigated and which steps have been taken and are yet to be taken. During the information meetings, people will have the opportunity to ask questions.

2.4.3 Draft NRD consultation procedure

This draft NRD will be made available for inspection and anyone who so wishes will have the opportunity to submit a statement of views. Responses can be submitted to the Energy Projects Office (Bureau Energieprojecten) of the Ministry of Climate Policy and Green Growth between 7 November and 18 December 2025. The Energy Projects Office requests that you submit your statements of views in digital format via the Programma Energiehoofdstructuur project page.

2.4.4 Statutory advisers and approval of the programme

The Netherlands Commission for Environmental Assessment (hereafter: NCEA) will be asked for advice about the level of detail and the scope of the IIA/SEA-r to be drawn up. This advice will be published and may result in additions and modifications to the approach for the IIA/SEA-r. Once the IIA/SEA-r has been drawn up, the NCEA will again be asked to advise on it. The Ministry of Infrastructure and Water Management, the Ministry of Agriculture, Fisheries, Food Security and Nature and the Ministry of Education, Culture and Science (Cultural Heritage Agency of the Netherlands) are statutory advisers.

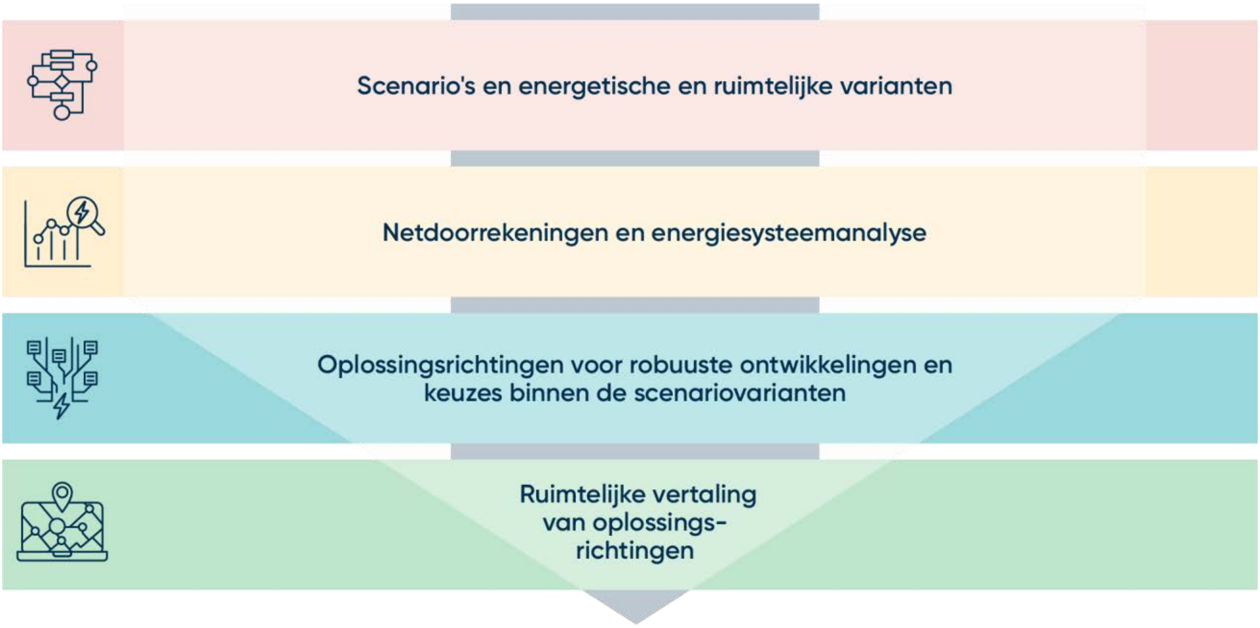
Formal approval of PEH II lies with the responsible ministers of Climate Policy and Green Growth, Housing and Spatial Planning, and Infrastructure and Water Management. The Minister of Climate Policy and Green Growth is the competent authority for the spatial planning of the national energy system. The Minister of Housing and Spatial Planning is a joint signatory, based on the portfolio's systemic responsibility for the Environment and Planning Act. The Minister of Infrastructure and Water Management is a joint signatory for the component relating to pipelines, in view of that minister's policy responsibility for pipelines. They are also involved in the establishment of the NRD and the IIA/SEA-r.

3 Development of alternatives

3.1 Introduction

The development of alternatives that will be assessed in the IIA/SEA-r takes place in different steps. Firstly, **scenarios** (section 3.2) and **variants** (section 3.3) are drawn up for the energy system that provide the basis for identifying the required energy infrastructure and bottlenecks in that infrastructure. The grid operators perform calculations for the scenarios and variants, and based on those we conduct an **energy system analysis** (section 3.4), which provides an overview of the energy infrastructure required in each scenario. This energy infrastructure is divided into components (such as high voltage power lines and hydrogen pipelines, batteries, underground storage and so on). Finally, based on the above, an assessment is made as to which components are essential in (nearly) all the scenarios and variants and which upgrades to the energy infrastructure are needed in (nearly) all of those scenarios and variants. These are **robust developments** (section 3.5). Solution pathways are identified for the robust bottlenecks or developments. An assessment is also made of the impacts of the **choices within the scenario variants** (section 3.5) on the energy system. These robust developments and choices are translated into spatial terms for the impact assessment.

Figure 3-1 Development of alternatives for the IIA



3.2 Scenarios

For the purposes of the Integrated Impact Analysis, an assessment is made of the (possible) developments of the energy system towards 2050, and the impacts of those developments. However, it is unclear what the world will look like in 2050 and how the energy system will develop. For this reason, different scenarios for the development of the energy system are used for the Integrated Impact Analysis. These scenarios are based on different assumptions about future developments, for example regarding the role of hydrogen carriers or the extent of self-sufficiency of the Dutch energy system. Integrated scenarios are elaborated. These integrated scenarios describe the total demand, supply, flexibility and energy infrastructure for all sectors and all energy carriers in volumes. The scenarios have a national scale (how much demand, generation, flexibility and energy infrastructure in the Netherlands as a whole?) but also a spatial distribution (where will this demand, generation, flexibility and energy infrastructure be realised?). With the help of integrated scenarios, including spatial distribution, an assessment is made of the total space required for national energy infrastructure and where that space is needed.

The use of different scenarios has various goals:

- To demonstrate the bandwidth of possible developments of the energy system, and the associated space requirements and impacts.
- To provide insight into the impacts of strategic choices for the configuration of the energy system.
- To provide insight into developments that recur in all scenarios, and are therefore expected to be necessary in any event. We call these robust developments.

The scenarios developed by Netbeheer Nederland in 2025 provide the foundation for developing the alternatives for the Integrated Impact Analysis. Because additional scenarios will be drawn up in the IIA for PEH II, we refer to the scenarios drawn up by Netbeheer Nederland as the 'base scenarios'. Four scenarios have been developed by Netbeheer Nederland. They are integrated scenarios including spatial distribution. Three scenarios are cornerstones of the possible developments, each with a focus on a different energy carrier (electricity, hydrogen carriers or (green) gas and biomass). There is also a single central scenario, 'Steady Middle Course' (*Koersvaste Middenweg*). Each of these scenarios assumes the achievement of the objective of a climate neutral energy system in 2050, but the path taken differs.

The four Netbeheer Nederland scenarios are called:

- **Steady Middle Course**; this is the central scenario. This scenario is closest to the direction of the NPE.
- **Own Capacity** (*Eigen vermogen*); this is the cornerstone scenario with a focus on electricity.
- **Joint Balance** (*Gezamenlijke balans*); this is the cornerstone scenario with a focus on (green) gas and biomass.
- **Horizon Supply** (*Horizon aanvoer*); this is the cornerstone scenario with a focus on hydrogen.

The four Netbeheer Nederland scenarios are visualised in the following figure. The table below provides an (incomplete) overview of key figures from these scenarios for 2050. A detailed description of the scenarios may be found in the scenario report by Netbeheer Nederland[10].

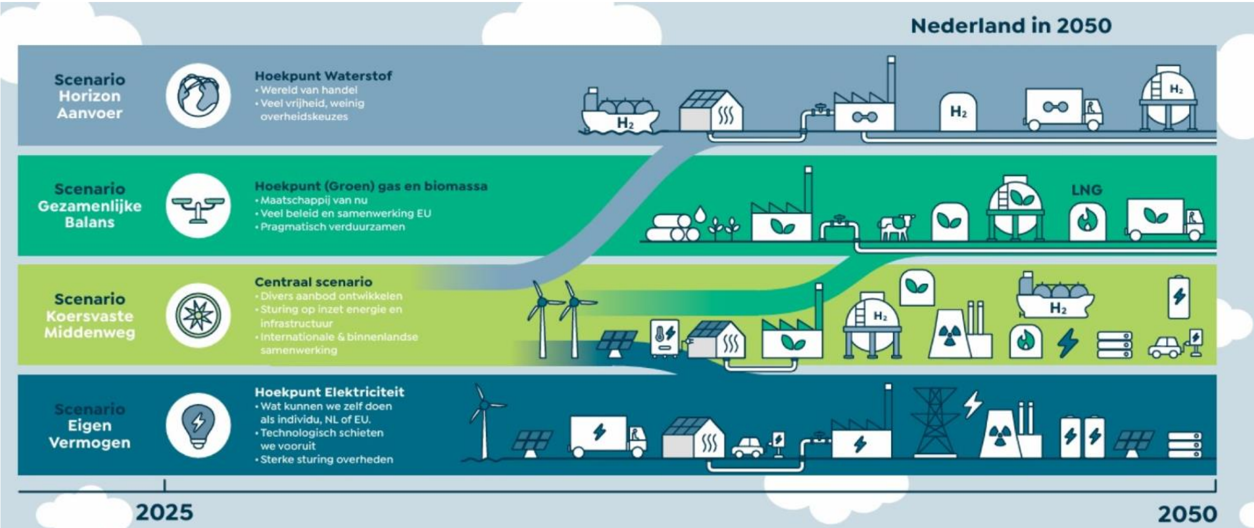


Figure 3-2 Four scenarios by Netbeheer Nederland

[10] Netbeheer Nederland scenarios edition 2025.

The following table reveals that the scenarios differ on important assumptions, such as the composition of energy demand, the development of generation from different sources and the Netherlands' dependence on imports. But there are also developments that are common to each of the scenarios. For instance, each scenario assumes a sharp increase in the use of electricity and production from wind turbines and solar panels. There is also a sharp increase in the number of batteries and electrolysers in each scenario.

Table 3-1 Most relevant key figures from scenarios for PEH II

	Steady Middle Course	Own Capacity	Joint Balance	Horizon Supply	
Energy demand					
Electricity demand	505	560	419	338	TWh
Hydrogen demand	68	77	36	133	TWh
Methane demand[11]	63	34	136	37	TWh
Heat demand	40	55	40	20	TWh
Biomass and bio-related fuels and raw materials	75	55	100	65	TWh
Application of CCS	40	25	85	20	Mt CO_2
Generation					
Offshore wind[12]	67	73	51	39	GW
Onshore wind	13	17	10	10	GW
Solar PV	116	174	101	77	GW
Nuclear energy (including SMRs)	6.9	5.5	3.2	2.0	GW
Flexibility					
Electrolysis	28	34	20	14	GW
Batteries	49	56	43	27	GW
Power plants	17	18	18	22	GW
Hydrogen storage	15	16	7	19	TWh
Net imports (imports minus exports)					
Electricity	29	36	35	48	TWh
Hydrogen	6	13	13	126	TWh
Methane	46	18	121	15	TWh

The above table relates to the scenarios for 2050; that year is also the focus for the Integrated Impact Analysis. However, the time path to 2050 is also important, particularly for the feasibility of the total (spatial) task of the energy transition. For this reason, an estimate is also made of the pace of the developments towards 2050. To this end, the investment plans of the grid operators and the scenarios for previous years are used. Netbeheer Nederland has also worked out the aforementioned scenarios for other target years, and these will also be used in developing alternatives.

Alongside the Netbeheer Nederland scenarios, additional scenarios will also be drawn up for the Integrated Impact Analysis: these are variants on the Netbeheer Nederland scenarios. The reasons for exploring alternative scenarios are:

- Greater bandwidth of potential developments: the purpose of using different scenarios is to investigate the full bandwidth of (realistic) potential developments. In some cases, the bandwidth

[11] This includes green gas and fossil natural gas.
[12] In the scenarios, it is assumed that the electricity generated by these offshore wind farms will be partially converted into hydrogen and transported to land by pipeline in that form.

of the Netbeheer Nederland scenarios is insufficient to encompass all possibilities, making additional scenarios desirable.
- The ability to explore specific research questions: a further reason for using scenarios is to gain insight into specific research questions. There are research questions about the composition of the national energy system, for example the impact if hydrogen carriers continue to play a minor role in the energy mix. Plus research questions about the spatial composition of the energy system, for example regarding the impact of defining preferred locations for battery systems. The Netbeheer Nederland scenarios are not sufficient to shed light on all research questions, so new scenarios will be drawn up for those.

The next section discusses which variants, all of them variants of the Netbeheer Nederland scenarios, will be elaborated and investigated, and what the purpose of investigating those additional scenarios is. Only new variants will be elaborated and investigated for 2050[13].

3.3 Energetic and spatial scenario variants

As described above, additional scenarios will be elaborated and investigated for the IIA, which are variants on the scenarios developed by Netbeheer Nederland.

3.3.1 Deciding on the content of the scenario variants

Two types of scenario variants will be developed in the IIA: energetic scenario variants and spatial scenario variants. In the case of energetic variants, the composition of the national energy mix is altered (for example, the quantity of energy generated by particular sources or the quantity of storage in the whole of the Netherlands differs relative to the base scenarios). In the case of spatial variants, the composition of the national energy mix remains the same as in the Netbeheer Nederland base scenarios, but the spatial composition (where demand, generation, storage are realised) is altered.

Energetic scenario variants
The design of the energetic scenario variants is based on spatial dilemmas revealed by the National Energy System Plan (NPE). The annual Climate and Energy Memorandum, in which target figures from the NPE can be adjusted, is also an important source, because not all developments are incorporated in the Netbeheer Nederland base scenarios, as these were not drawn up with the primary objective of making spatial policy and/or investigating the spatial impacts if particular developments fail to materialise. Energetic scenario variants will include options for swapping out different flex functions. For example, a scenario variant will be considered in which hydrogen storage lags behind and less electrolysis is realised while the share of offshore wind energy remains the same. An energetic scenario variant will also be drawn up in which the spatial impacts of a different level of energy demand from industry are explored. The most recent Climate and Energy Memorandum proposes a more ambitious target for CCS and a lower target for offshore wind energy for 2040. Because these volumes can also be investigated using the base scenarios, no separate scenario variants need to be drawn up for them in the IIA for PEH II.

Spatial scenario variants
Based on the draft National Spatial Strategy, the following design principles will be used for the spatial scenario variants. The principle of aligning supply and demand spatially is a key issue for the IIA and recurs in multiple spatial scenario variants, such as exploring the spatial distribution of offshore wind landfall sites[14] or alternative preference areas for nuclear energy. The draft National Spatial Strategy also stresses the importance of carefully considering the allocation of space in the industry clusters. This

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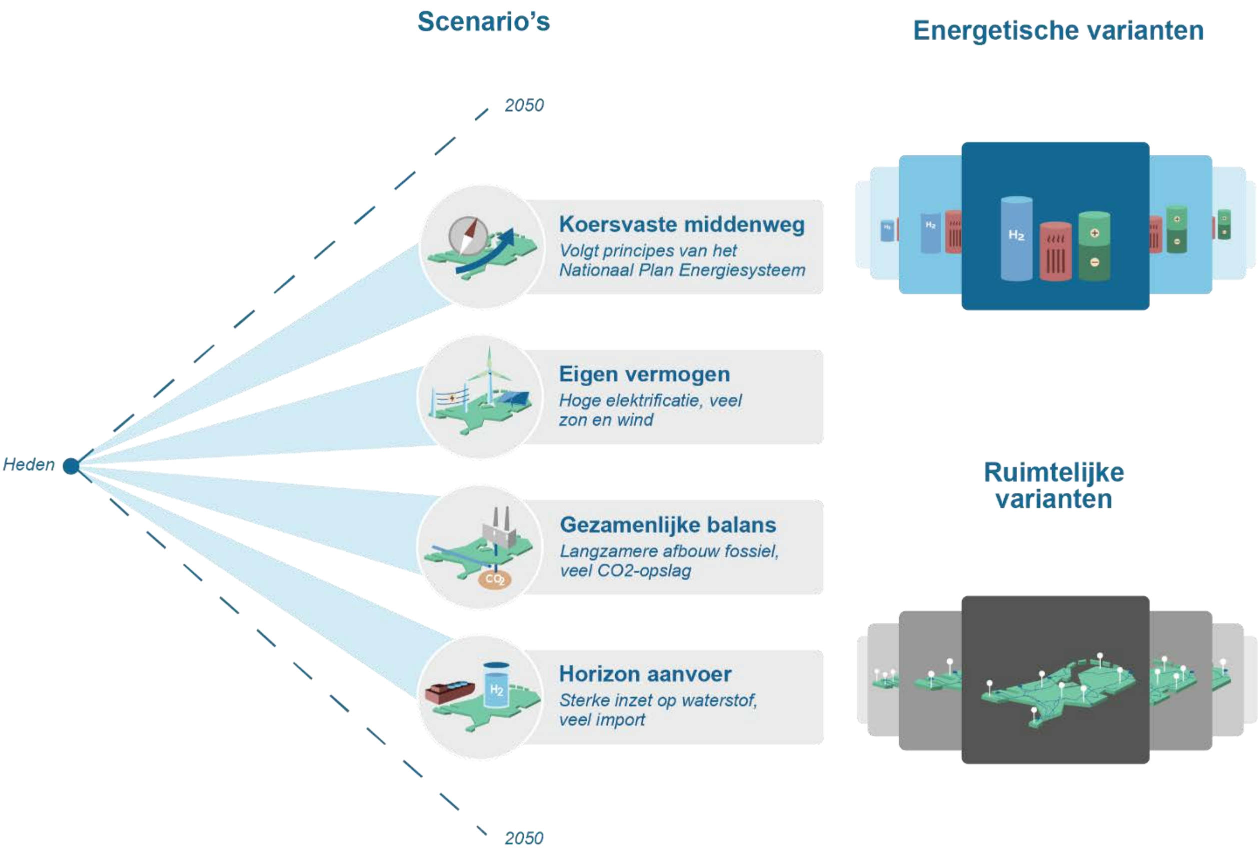
[13] The developments around (hazardous) substances, to the extent that they do not fall within the scope of the scenarios and scenario variants, will be investigated in a separate analysis for the PEH II IIA.
[14] This has no influence on the choices in the VAWOZ programme for 2040.

results in spatial scenario variants in the IIA for PEH II, for example a scenario variant that explores the distribution of batteries to locations outside the industry clusters and seeks to identify locations for deep landfall sites. Finally, careful treatment of the water system is an important consideration for the draft National Spatial Strategy. Among other things, this leads to a variant in which power plants are sited only on the coast so that no pressure is created on the freshwater system. The draft National Spatial Strategy addresses many other spatial challenges. These challenges are taken into account in the space and environment impact assessment (see section 4.3).

Figure 3-33 Energetic and spatial scenario variants



3.3.2 Working method when drawing up scenario variants

Based on dilemmas and research questions, a number of **energetic scenario variants** will be elaborated and investigated in the IIA. This will shed light on the consequences of the failure of particular developments of supply and demand to materialise in the future. Three energetic variants are elaborated:

- **Less electricity storage with batteries.** Each of the four Netbeheer Nederland scenarios assumes a significant development of battery storage (from 27 to 56 GW in total). It is likely that the future energy system will incorporate more batteries than there are today, but some studies anticipate a smaller role for batteries in a climate neutral electricity system than the Netbeheer Nederland scenarios[15]. For this reason, a variant will be explored involving less battery storage, in order to be better aligned with the bandwidth of possible developments and their impacts on the energy infrastructure and to investigate the space required for the energy system. In this scenario, the reduction in battery storage is compensated by more dispatchable hydrogen power plants and greater use of other sources of flexibility (such as long-term storage, interconnection and

[15] *For example in this study into a zero-carbon electricity system in 2035.*

electrolysis). In the Netbeheer Nederland scenarios, system batteries have a storage volume of 8 hours (relative to capacity)[16]. We make the same assumption in this variant. We also consider the impacts at a different storage volume, for example 4 hours.

- **Less electrolysis and hydrogen storage.** The size of the role of hydrogen carriers differs between the four Netbeheer Nederland scenarios, but each of the scenarios foresees a significant hydrogen demand (34 – 136 TWh) and domestic production of green hydrogen with electrolysis (14 – 34 GW). This means that in each of the scenarios, a substantial amount of hydrogen storage is needed (7 – 19 TWh). However, the development of electrolysis is proceeding less quickly than expected, due in part to higher costs, and it is conceivable that the role of electrolysis will be smaller than the bandwidth of the Netbeheer Nederland scenarios. It is also uncertain how much hydrogen storage can be realised underground. For this reason, a variant has been elaborated with less electrolysis and less hydrogen storage. In this variant, hydrogen demand is kept constant. The reduced domestic hydrogen production is compensated by increased hydrogen imports and, due to the reduced demand for electricity for electrolysers, the quantity of offshore wind is scaled back in this scenario. Given a smaller available capacity for hydrogen storage, in this variant power plants, which are needed at times of little wind and sun, run on green gas (and not on hydrogen as in most of the Netbeheer Nederland scenarios).
- **Alternatives for meeting demand from industry.** The future development of industry in the Netherlands will have a major impact on the design of the energy system, given that this sector is responsible for a large share of energy demand in the Netherlands. One possible future configuration of industry would involve more semi-manufactures being imported, so partially removing (energy-intensive) process steps in the Netherlands, meaning that only the later steps in the production process would take place in this country. This variant will explore the implications of increased imports of semi-manufactures for the energy system. Additionally, a reduced development of demand from datacentres will be assumed in this variant, compared to the base scenario. It is important to note that this is not a goal but a possible development for which it is desirable to map out the implications and the associated space requirements for the energy system. In this variant, the quantity of renewable generation, particularly from offshore wind, and the quantity of imports, will also be adjusted based on the changes in energy demand.

TenneT Target Grid scenario
Parallel to the IIA process for PEH II, TenneT is going through the Target Grid process for the second time, which will result in a long-term vision of their future network. To this end, TenneT has drawn up a new scenario. This scenario, and the associated insights from TenneT's calculations for Target Grid, will also be used for the IIA in order to ensure consistency between the two pathways.

In addition, different **spatial variants** will be elaborated. These will provide insight into the impact of spatial choices for the configuration of the energy system and the desirability of defining preferred locations for particular components of the energy system (such as batteries). The spatial variants can also provide insights for other policy pathways. Spatial variants of the Netbeheer Nederland scenarios are being elaborated for the following developments[17]:

Deep landfall sites for offshore wind[18]

[16] Other forms of electricity storage are also included in the scenarios, such as home batteries, storage of electricity in electric vehicles, batteries in solar farms and different forms of long-term storage. These have different storage volumes.
[17] Additional spatial variants may be added if this proves desirable at a later point in the process.
[18] The insights about the impact of deep landfall sites for offshore wind on the energy infrastructure will also be taken into account in the Preliminary Study into Deep Landfall Sites for Offshore Wind Energy.

In connection with the preliminary study into deep landfall sites for offshore wind, different variants will be elaborated. The variants differ in terms of the locations of deep electrical landing of offshore wind. The following principles were used in the selection of locations for deep landing: the locations are not part of PAWOZ and the VAWOZ programme, do not lie in coastal provinces, are distributed throughout the Netherlands, there is a possibility to connect to a 380kV substation (both in terms of capacity and spatially and either now or in the future following potential upgrades), along with a consideration of system efficiency (taking account of (the development of) local demand, interconnection and the impact of landing on bottlenecks in the high-voltage network). This led to the following potential regions for landfall locations being identified:

- Limburg
- South Gelderland/East Brabant
- Twente
- Flevoland

The goal of performing calculations for these variants with deep landfall sites at these locations is to determine what their impact would be on the electricity infrastructure and the system integration of offshore wind.

Supplementary nuclear energy ambition

The outline coalition agreement (*Hoofdlijnenakkoord*) of the Schoof government presents the ambition of building two additional conventional nuclear power plants, supplementary to the two new conventional nuclear power plants announced under the Rutte IV government. Exploring options for multiple small nuclear power plants (Small Modular Reactors (SMRs)) is also part of current government policy.

The Ministry of Climate Policy and Green Growth (as the initiator) is currently working through a project procedure for the choice of location for the first two conventional nuclear power plants, with locations being considered in Sloegebied, Terneuzen, Maasvlakte II and Eemshaven. With regard to the construction of the first two new nuclear power plants, the government has adopted the principles and considerations established previously when updating the safeguarding policy, for example in the Third Electricity Supply Structure Plan (SEV III), and confirmed in later spatial policy.

Due to time and cost benefits, for the realisation of the first two nuclear power plants it has been decided that at least two reactors will be built at a single location, both of them generation III+ and with a capacity of at least 1,000 MW. The Letter to Parliament on nuclear energy of May 2025[19] indicated that for as part of PEH II, the desirability of adopting different principles for the siting of new nuclear capacity would be examined, based on the overall challenge for our future energy system and in connection with other spatial aims.

The above entails two changes for PEH II compared to PEH I and the current project procedure for the siting of nuclear power plants 1 and 2. Firstly, PEH II is not exclusively concerned with the siting of conventional nuclear power plants, but also with space for SMRs. It looks at nuclear capacity within an area and not the siting of specific numbers of power plants. Secondly, PEH II will consider whether spatial principles are needed for the future siting of nuclear capacity in the Netherlands after nuclear power plants 1 and 2, and if so what those principles should be.

[19] *Parliamentary Papers 2024/2025 32645-156*

Draft National Spatial Strategy on new preference areas for nuclear power plants

The draft National Spatial Strategy specifies that the choice of preference locations for nuclear power plants 3 and 4 will be guided by the National Energy Network Development Plan (PEH). In that context, the desirability of adopting different (spatial) principles than those followed for power plants 1 and 2 will be examined, based on the overall challenge for our future energy system and in connection with other spatial aims. Important considerations in identifying preference areas include impact on the energy system, availability of cooling water and (long-term) availability of (physical and environmental) space.

The pronouncements for each consideration in the National Spatial Strategy are shown below:

- **Impact on the energy system**
  - Due to scarcity of new energy infrastructure and sustainable energy carriers, we have adopted an 'energy planology' approach, which involves anticipating the spatial requirements of the new energy system on the one hand and programming spatial developments in such a way that they contribute to an effective and efficient energy system on the other.
  - Spatially aligning supply and demand is one of the core principles of the draft National Spatial Strategy for energy. The aim is to reduce the spatial and infrastructural impact throughout the country. By making smart choices and distributing production locations, supply and demand can be optimally matched.

- **Availability of cooling water**
  - The availability of (brackish/saline) (cooling) water can only be guaranteed year-round along the coast. Inland, shortages of freshwater can arise during hot, dry summers and restrictions may apply to the discharge of cooling water for reasons of water quality and temperature. This will be taken into account in the choice of location.
  - Water users can anticipate this, for example by avoiding locations where freshwater availability cannot be guaranteed in the long term.

- **Availability of physical space**
  - Existing space in industrial estates and environmental space will be protected as far as possible.
  - We will seek to identify suitable locations for infrastructure upgrades based on the relationships between the energy system, economic development, capacity in the networks, space for defence and broader spatial and societal aspects (such as the quality of the living environment). The outcome may be a strategic expansion of industry clusters.

- **Availability of environmental space**
  - We want to better utilise the existing environmental space by only permitting activities in areas already subject to environmental impacts that need this environmental space.
  - We are committed to carefully handling high-quality locations, such as locations where activities with a high environmental impact take place.

PEH II will examine whether there are any (new) areas suitable for the construction of additional nuclear power plants at regional level. A number of technical prerequisites rule out large parts of the Netherlands for the siting of nuclear power plants. These prerequisites are:

- Availability of cooling water, possibly with cooling towers.
- No nuclear power plants in the vicinity of densely populated areas: not more than 5,000 residents within 1 km of the search areas, as laid down in the Living Environment (Quality) Decree (BKL).
- No nuclear power plants in Natura 2000 areas, as laid down in the BKL.
- No nuclear power plants in UNESCO world heritage sites, as laid down in the BKL.

- Not situated within a distance of 5 km from a geologically active fault line, as laid down in the SSG 9 safety standard[20].

The actual suitability of regions in the Netherlands for the siting of additional nuclear power plants will be investigated in the IIA. Many more factors are involved, such as integration into the energy system, environmental and spatial impacts, safety aspects and cost.

Distribution instead of concentration of system batteries

The Integrated Impact Analysis for PEH I revealed a high demand for space in the industry clusters because multiple developments of the energy system come together there (and space is also needed for industry itself). The analyses showed that to a significant extent, industry clusters would represent the most system-efficient locations for batteries. However, it is not clear what the impact would be on the power grid if those batteries were distributed more widely throughout a region. In this variant, no batteries would be placed in industry clusters. The batteries would instead be constructed at other locations in the Netherlands. Exploring this variant should provide insight into whether spatial bottlenecks would arise at other locations in the Netherlands if batteries were not placed in the industry clusters and what the impact of that would be on the required energy infrastructure.

Electrolysis and power plants on the coast

Due to climate change, the availability of water in the interior of the country may decline over time, and may be insufficient for large users of water such as electrolysers and power plants. For this reason, a spatial variant is being explored in which these large users of water are located primarily on the coast.

Distribution of landfall sites for offshore wind on the coast

Landing electricity from offshore wind has a major impact on the national energy infrastructure. The Exploration of Offshore Wind Energy Landing (VAWOZ) programme makes choices with regard to landfall sites for offshore wind up to 2040. The insights from the VAWOZ programme, which will be published in 2026, are already being used to inform the spatial distribution of landfall sites on the coast. Between 2040 and 2050, additional landfall sites for offshore wind will be constructed in each scenario. Based on the insights from the VAWOZ programme, an assessment will be made of the most efficient distribution of landfall sites for offshore wind on the coast after 2040.

Location of datacentres

The Netbeheer Nederland scenarios foresee substantial growth in electricity demand from datacentres, due in part to the development of artificial intelligence. In the scenarios, most of these datacentres will be built in Noord-Holland, near Amsterdam, and in Groningen, near Eemshaven. A spatial variant will be explored in which some of the new datacentre capacity is located at a new hyperconnectivity cluster in Flevoland.

Imports of hydrogen carriers

In each of the Netbeheer Nederland scenarios, hydrogen carriers are imported, both for domestic use and for transport to the hinterland. The hydrogen carriers are imported in different forms (ammonia, liquid, LOHC[21]) and enters the country at Rotterdam, Zeeland, the North Sea Canal area and Eemshaven. Most of the imports come through Rotterdam. A spatial variant will explore the impact of concentrating those imports in just two regions: Rotterdam and Eemshaven. These are the two locations where imports of LNG already take place and where there will be a strong hydrogen network in the future. Most of the initiatives for importing hydrogen carriers are also centred on Rotterdam.

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[20] IAEA safety standard SSG-9 “Seismic Hazards in Site Evaluation for Nuclear Installations” (2010).
[21] Liquid Organic Hydrogen Carrier. A technique in which hydrogen is chemically bonded to an organic compound in order to make it easier to transport.

Building on PEH I

With the above scenario variants for PEH II, we are building on the insights from PEH I (2024). For example, PEH I revealed that constructing large-scale electrolysers at offshore wind landfall sites is efficient for the energy system, and as such offers significant space and cost benefits. Further to that insight, we will be investigating the impact of siting large users of water (such as electrolysers) on the coast due to the possible future scarcity of water in the interior of the country. PEH I also demonstrated that spatial concentration of electricity production from wind and solar (as opposed to distribution) would not result in significant impacts on the high-voltage infrastructure. This issue will therefore not be addressed in PEH II. Another example is the extensive space requirements in industry clusters highlighted by PEH I. In PEH II, we will explore to what extent those space requirements can also be met at other locations.

3.4 Energy system analysis and determining the required energy infrastructure

The development of demand, supply, flexibility and the required energy infrastructure will be determined for the scenarios and for the energetic and spatial scenario variants. In order to anticipate the development of demand, supply and flexibility, assumptions have been made in each of the scenarios. How these were arrived at was discussed in the preceding two sections.

The required energy infrastructure is a consequence of the development of demand, supply and flexibility. In order to determine the required electricity infrastructure and gas infrastructure (methane, hydrogen and CO_2), network calculations are made by the national grid operators (TenneT and Gasunie). A network calculation will be performed for each of the scenarios discussed previously, including the energetic and spatial scenario variants. The focus of the network calculations by both TenneT and Gasunie is the national transport network – the 380kV and 220kV network in the case of TenneT and the main transmission network in the case of Gasunie. TenneT will also calculate requirements for coupling transformers between 220/380 kV and the future pockets[22] in the regional high-voltage networks (110/150 kV). Calculations will be made for the coupling transformers and power lines in the regional high-voltage networks. The load on the coupling transformers determines whether new pockets need to be created, which in turn would necessitate a new coupling transformer. In addition to calculations for the main transmission network, Gasunie will also perform a qualitative analysis to establish whether branches need to be added to the network.

Impact on regional energy infrastructure

The focus of PEH II is on the national energy infrastructure, i.e. the 380kV and 220kV network (TenneT) and the main transmission network (Gasunie). As discussed above, TenneT and Gasunie will be performing additional analyses: for the regional high-voltage network (150/110kV) and the coupling transformers in the case of TenneT and possible branches of the main transmission network in the case of Gasunie. These are the developments that will have the biggest spatial impact, and therefore have the greatest significance for PEH II. Other developments in regional energy infrastructure will not be investigated, due in part to the increased uncertainty with regard to developments at this level. Such developments will be explored further in regional programmes and pathways, for example provincial energy visions.

[22] In order to create space in the network, TenneT will be splitting the 110kV and 150kV high-voltage network into more than 40 smaller areas. Each of these so-called pockets will have their own connection to the 220kV and 380kV high-voltage network.

The network calculations will reveal potential bottlenecks caused by the expected developments in the energy infrastructure. Solution pathways to resolve these bottlenecks will then be identified. These could be upgrades to the energy infrastructure or operational solutions (such as redispatch[23]), but also alternatives such as system solutions – for example, alternative locations or deployment of sources of production or flexibility – and market interventions.

Relationship with existing grid congestion problems
Large parts of the Netherlands currently suffer from grid congestion, due to the fact that there is insufficient available capacity in the power grid. The IIA for PEH II will explore which solution pathways for the power grid are essential in order to ensure sufficient capacity in the power grid in 2050 and how much space they will require. These analyses will not yield solutions to existing grid congestion problems, but they will shed light on how much space is needed in order to prevent future grid congestion as far as possible.

DC hubs will be specifically considered as a possible solution pathway for bottlenecks in TenneT's high-voltage network. A DC hub is a switching station between two (or more) DC power lines, where direct current power lines meet and/or they connect with the AC network (more on this in Table 1-1 in section 1.1). The IIA for PEH I and other studies by TenneT (such as the investment plan and Target Grid) reveal that a lot of electrical transport capacity will be required from the coast to the interior. This can be achieved with overhead high-voltage lines, but the possibility is also being considered of creating DC hubs in the interior with underground DC cables extending inland, in view of the fact that (temporarily) creating new overhead high-voltage lines is highly challenging in spatial, technical and organisational terms. Whether it is possible to include DC hubs in network calculations, and to determine to what extent these hubs will resolve bottlenecks in the regular overhead high-voltage network, is dependent on the development of modelling of DC hubs by TenneT.

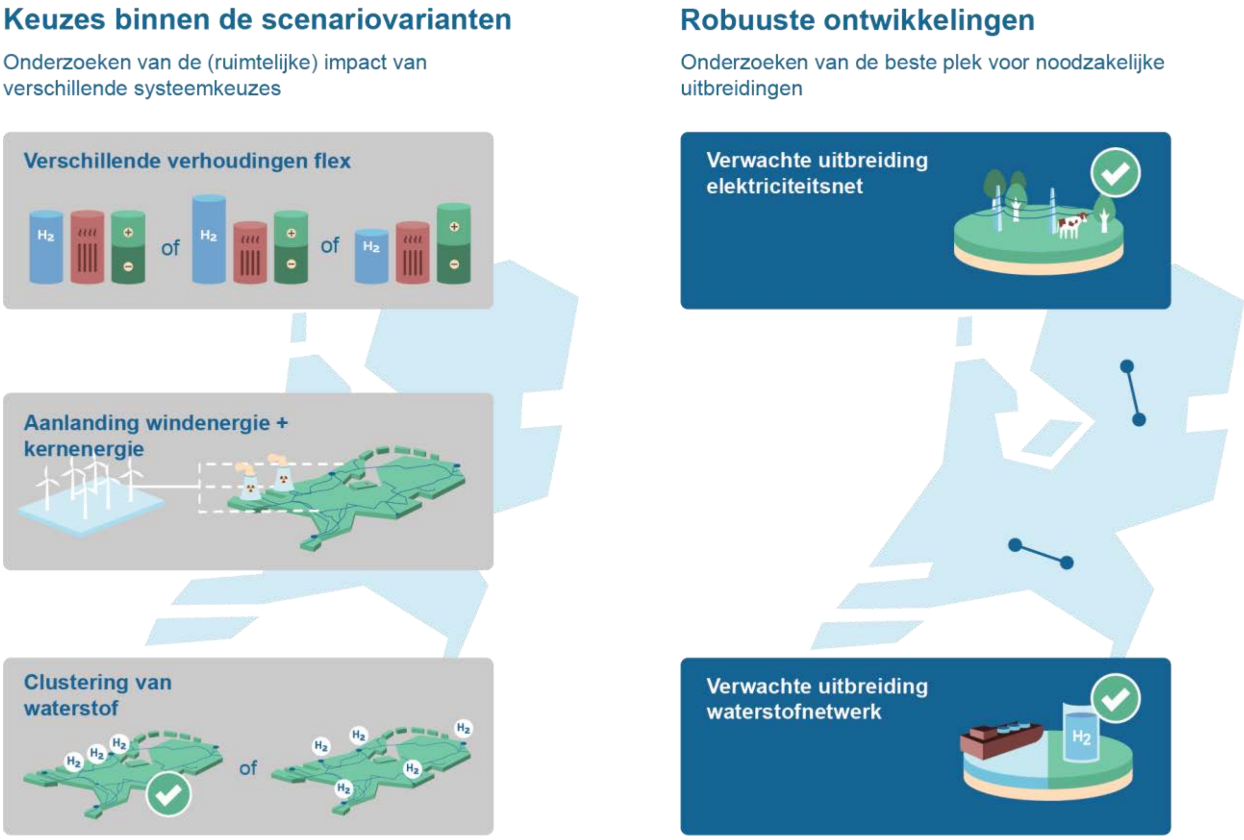
There are also other components of the energy infrastructure for which the grid operators do not perform network calculations but that will be investigated in the IIA for PEH II. This applies to supraregional heat infrastructure and pipelines for fuels and raw materials (with the exception of hydrogen, for which analyses are performed by Gasunie). Separate analyses will be carried out in these cases, based on the expected development of supply and demand of the carriers in question.

3.5 Development towards robust developments and choices within the scenario variants

The elaboration of the scenarios and energetic and spatial scenario variants, taken together with the analyses into the required energy infrastructure, will yield an overview of the required components of the energy system **per scenario.** An assessment will then be made as to which components are essential in (nearly) all scenarios and scenario variants, and which upgrades to the energy infrastructure are needed in (nearly) all scenarios and scenario variants. These are **robust developments**. The impacts of the **choices within the scenario variants** on the energy system will also be assessed. These choices are embedded in the scenarios and scenario variants, which means that their impacts can be revealed by comparing the outcomes of the scenarios and variants. If particular components or upgrades to the energy infrastructure have great societal added value (according to the assessment), this may lead to preferred locations being identified for them.

[23] *Redispatch is mechanism whereby TenneT pays consumers or producers of electricity to reduce their production or consumption or, conversely, to increase it in order to reduce the flow on a power line where there is a risk of a bottleneck. This is cheaper than building new infrastructure if bottlenecks only occur a few times per year on a particular power line.*

Figure 3-44 Examples of choices within scenario variants and robust developments

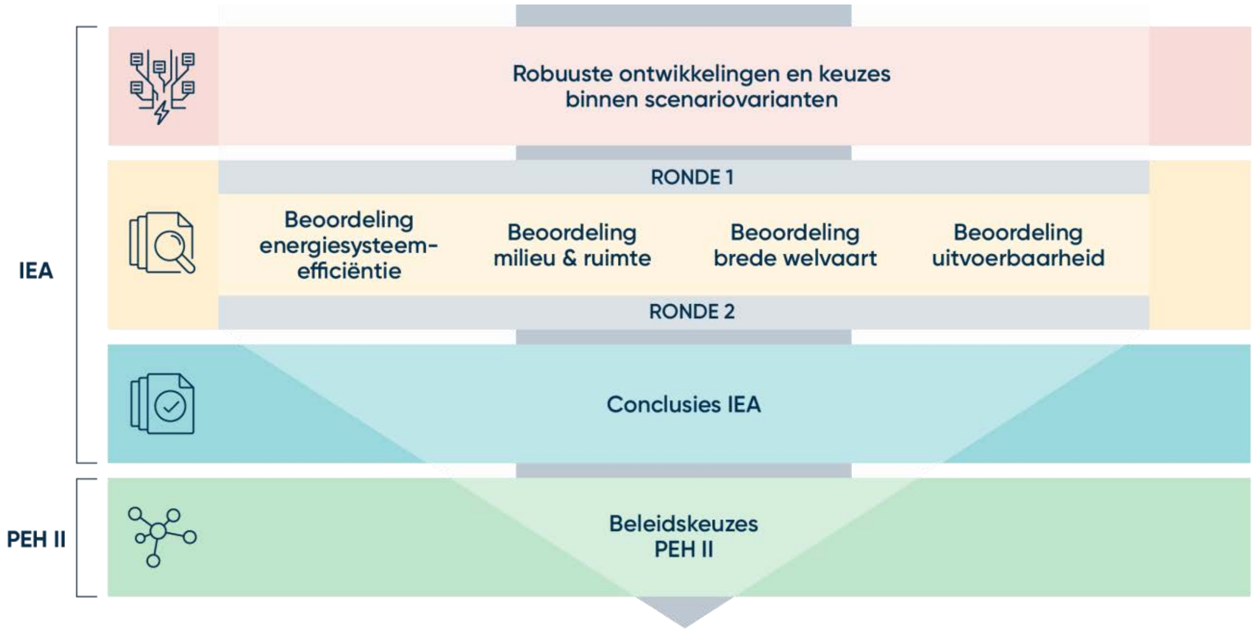


4 IIA/SEA-r assessment methodology

4.1 IIA assessment framework

The assessment framework consists of four themes to be assessed: energy system efficiency, environment & space, well-being and feasibility. The assessment takes the form of two research rounds: round 1, in which the research is exploratory and broad in nature, and round 2, in which the research is in-depth and focused. The assessment framework and the assessment methodology are described in brief in the sections below. The Environment & Space theme adds detail to the SEA-r, including the prerequisites attached to an SEA-r. The level of detail of the assessment is appropriate to the nature of PEH II.

Figure 4-1 Explanation of assessment methodology



4.2 Explanation of the Energy system efficiency assessment methodology

One of the components of the assessment is the theme of Energy system efficiency. Matching supply, demand and storage of energy will play an important role in the efficiency of the future energy system. For this theme, an assessment is performed for the choices within the scenario variants and for the comparison of different solution pathways for bottlenecks in the energy infrastructure (see section 3.4). This means that assessments are not made for all components of the energy system and the robust developments for the Energy system efficiency theme. This is because this aspect is only important if choices can be made.

Energy system efficiency means the optimal matching of supply and demand of energy in time, mode (energy carrier) and space; managing energy and the robustness of the energy system in the most efficient way possible. The choices within the scenario variants and different solution pathways for bottlenecks in the energy infrastructure are assessed on these criteria. The different forms of energy are considered: electricity, hydrogen, methane and, where relevant, heat.

The Energy system efficiency assessment will consist of two rounds; the first round will comprise an overall assessment for all choices within the scenario variants and solution pathways for bottlenecks in the energy infrastructure. This will be followed by a second round taking a more in-depth look at bottlenecks and choices for which this is desirable.

The most important aspects considered in the energy system efficiency assessment are:

- **Required energy infrastructure.** Energy needs to be transported from the production locations to the demand locations. This requires energy infrastructure. The required energy infrastructure is determined in this aspect. This is a measure of the efficiency of the utilisation of this infrastructure. System optimisation, defining preferred locations and market interventions can limit the challenge for new energy infrastructure.
- **Balance between supply and demand.** Flexibility is required in the energy system in order to match supply and demand over time. The future energy supply in the form of electricity will be less constant than the current one, which means the need for flexibility will grow. That flexibility can be achieved through energy storage, conversion, exchanging energy with foreign countries and demand management. The number of sources of flexibility needed to achieve equilibrium between supply and demand will be mapped out in this aspect. Increased system efficiency can improve the balance between supply and demand and reduce the sources of flexibility required.
- **Security of supply.** Security of supply refers to the degree to which consumers can rely on the supply of energy at any point throughout the year. A qualitative review will be conducted of the impact of strategic choices on the robustness of the energy system and security of supply in the event of emergencies.
- **Energy losses.** Energy is lost during the conversion, storage and transport of energy. This means that in order to meet any particular level of demand, a greater quantity of energy needs to be produced than is consumed. This will also be taken into account in the assessment.

4.3 Explanation of the Environment & Space assessment methodology

For the Environment & Space theme, we will assess the solution pathways for robust bottlenecks and the impacts of infrastructure or space that are required only for specific scenario variants. Solution pathways can relate to a single component of the energy infrastructure, but a solution pathway can also be a set of solutions. The Environment & Space impact assessment takes place in two rounds. Round 1 is a broad assessment, while round 2 is an in-depth assessment. In the first round, all the components of the energy infrastructure that fall within the scope of PEH II are assessed. For round 2, a selection is made of specific components (location/area), and an in-depth assessment is made for those specific components.

4.3.1 Aspects to be assessed

The aspects assessed for the Environment & Space theme are divided into four primary aspects. Each primary aspect is worked out into multiple sub-aspects. The primary aspects and sub-aspects are shown in the following table.

Table 4-1 Primary aspects and sub-aspects within the PEH II IIA

Primary aspect	Sub-aspect	Description
Nature	Natura 2000 areas Netherlands Nature Network (NNN) Other protected areas Protected species	We conduct the assessment based on different evaluation frameworks for protected areas and species; we also consider nitrogen deposition.
Spatial quality and cultural heritage	Landscape of value Cultural heritage	We investigate the impacts on landscape, cultural heritage and archaeological values, including (cultural)

Primary aspect	Sub-aspect	Description
	Experiential, future and usage value	landscapes of value such as UNESCO World Heritage Sites. In doing so, we also consider contributions to spatial quality, for instance through opportunities for combining energy infrastructure.
Living environment, environment, health and safety	Soil and water Climate adaptation Noise External safety	Here we investigate sub-aspects that are related to various industrial, residential and work functions. We are concerned with direct (physical) and indirect space, for example for noise. A number of evaluation frameworks are based on health, for example the evaluation framework for noise. We also consider future resilience in terms of soil and water and climate adaptation. The development of urbanisation locations is included in the reference situation (current situation plus autonomous development). In view of the level of abstraction of PEH, aspects such as EMF[24], air and odour are not considered for PEH, beyond identifying the numbers of residents.
Other land use	Agriculture Recreation Defence Industry Economy Infrastructure Housing Underground land use	We assess the impacts of the energy infrastructure on the agriculture, recreation, defence, industry, economy and infrastructure (road, rail, water, solar and wind energy) functions. In doing so, we also consider opportunities for multifunctional land use.

The environmental and spatial impacts are assessed using the assessment scale below. In view of the level of detail of PEH II and the assessment, symbols are used instead of pluses and minuses to express the mostly qualitative assessments. The assessment uses a 4-point scale because it is anticipated that the impacts will generally be neutral or negative and there are limited positive impacts. However, potential opportunities to make a positive contribution to the surrounding area by means of energy infrastructure are explored.

Symbol	Meaning
▲	Positive impacts compared to the base situation
●	Few or no impacts compared to the base situation
▼	Negative impacts compared to the base situation
▼▼	Highly negative impacts compared to the base situation

Where negative impacts make energy infrastructure impossible, these ‘showstoppers’ are described.

4.3.2 Differentiation in assessment frameworks used

Various assessment frameworks are used for the assessment of the Environment & Space theme. The assessment framework is elaborated in more detail for each component of the energy infrastructure and per research round. This is because the desired level of detail and focus of the assessment framework depends on three aspects:

[24] *Precautionary policy has been drawn up for EMF. This policy applies if potential routes for high-voltage power lines are known. This is not relevant for PEH, due to the high level of abstraction. Under the precautionary policy, EMF is catalogued at project level at a later stage. This may result in alternative routes being optimised, compared and assessed, and in source measures being taken as described in the precautionary policy.*

- The component of the energy infrastructure
- The policy choice to be made
- Whether the assessment takes place in research round 1 or 2

Differentiation per component of the energy infrastructure

Each component of the energy infrastructure has its own characteristics in terms of environment and space. This means that not all environmental aspects are relevant for all types of energy infrastructure. For this reason, an assessment framework is developed for each component of the energy infrastructure, with different aspects being assessed. For each component of the energy infrastructure, the table below specifies the nature and characteristic of the type of energy infrastructure (is it a line or is it a location (point)), along with the most significant potential impacts. In the follow-up process, this table will be worked up into a final assessment framework. NB: for various components, the impact specified is ‘physical space’ – by this is meant land-take that may have an influence on other functions such as nature, agriculture, industry, etc.; these functions are not summed up in the table.

Table 4-2 Characteristic, nature and most significant potential impact of each component of the energy infrastructure

Component of the energy infrastructure	Characteristic and nature of the component	Most significant potential impacts
High-voltage power lines (including substations)	Above-ground line and point infrastructure	Nature reserves, birds, landscape, world heritage, physical and environmental space
Power plants	Above-ground point infrastructure	Physical and environmental space (noise and safety), cooling water (extraction and discharge), landscape
Batteries	Above-ground point infrastructure	Physical and environmental space (noise and safety), landscape
Electrolysis	Above-ground point infrastructure	Physical and environmental space (noise and safety), water availability e.g. for cooling water (extraction and discharge), landscape
Pipelines	Below-ground line infrastructure	Physical and environmental space (safety) in the underground, soil and water, archaeology
Hydrogen storage	Below-ground and above-ground point infrastructure	Physical space in the underground, soil and water, archaeology, environmental space (safety)
Deep landfall sites	Below-ground line infrastructure and above-ground point infrastructure	Line: physical space and environmental space (safety, soil and water, archaeology) in the underground Point: physical and environmental space (noise), landscape
DC hubs	Above-ground point infrastructure	Physical and environmental space (noise), landscape
Nuclear energy preference areas	Above-ground point infrastructure	Physical and environmental space (noise and safety), cooling water (extraction and discharge), landscape
Fuel import terminals	Above-ground point infrastructure	Physical and environmental space (safety)
CO_2 capture, transport and storage	Below-ground line infrastructure and above-ground point infrastructure	Line: physical space in the underground, soil and water, archaeology Point: physical and environmental space (noise, safety), landscape
Heat infrastructure	Below-ground line infrastructure and above-ground point infrastructure	Line: physical space in the underground, soil and water, archaeology Point: physical and environmental space, landscape

Differentiation due to policy choice to be made

The level of detail at which an assessment takes places is also guided by the policy choices to be made (spatial reservations, spatial developmental trajectories, generic spatial policy, strategic vision development) for a particular type of energy infrastructure. Moreover, there are existing spatial reservations for different components of the energy systems, for which we assess the future resilience. Three examples are given below to illustrate this.

New spatial reservation as a policy choice: if it is desirable to make a spatial reservation for an area for a particular component of the infrastructure in PEH II, a more detailed impact assessment is possible and

necessary. For example, the aspect of nature may then be assessed for the specific natural values present in that area rather than the land-take in or close to a nature reserve.
Revision of existing reservations as a policy choice: the existing land reserved for pipelines may leave too little room for all future pipelines. PEH II assesses whether the existing reservations can meet that future demand.

Strategic vision development as a policy choice: in order to develop a strategic vision of a particular subject, less detailed information is required. An example of a strategic vision is the choice between concentrating batteries in particular areas or installing them in a distributed fashion. For decisions of this kind, location-specific information is not yet available and is less relevant. For this reason, the impact assessment can remain at a lower level of detail – for example, what are the differences between the choices in terms of spatial impacts?

Differentiation per research round

Finally, the assessment framework may vary depending on the research round. As stated previously, exploratory research takes place in research round 1, while in-depth research takes place in research round 2. This means that the aspects are assessed in a different way in rounds 1 and 2 in order to gather information at the right level of detail. A number of examples are shown in the table below – the list is not exhaustive. In the follow-up process, this table will be worked up into a final assessment framework.

Table 4-3 Elaboration of some examples of differentiation in assessment criteria per research round (not exhaustive)

Primary aspect	Sub-aspect	Methodology for round 1	Methodology for round 2
Nature	Natura 2000	Land-take and traversing of Natura 2000 areas	Habitat degradation, disruption, drying out, eutrophication/acidification based on disruption contours for benchmark species, drainage contours, inventory of nitrogen-sensitive areas
Spatial quality and cultural heritage	Landscapes of value	Land-take and traversing of landscape areas of value	Identification of impacts on spatial quality based on the specific landscape characteristics of the area
	Cultural heritage (archaeology component)	Land-take and traversing of areas with known and expected archaeological values	Land-take and traversing of areas with known and expected values
Living environment, environment, health and safety	Soil	Land-take and traversing of areas with different soil types	Identification of impacts based on soil characteristics
	Noise	Number of noise-sensitive land uses around search areas	Identification of noise impacts using contours around search area based on reference installation for, e.g., an electrolyser
Other land use	Agriculture	Land-take and traversing of agricultural areas	Land-take and traversing per type of agricultural land
	Infrastructure	Number of traverses per type of infrastructure	Impacts on characteristics of infrastructure, e.g. type of flood defence

Follow-up procedure and level of detail

In order to realise energy infrastructure described in PEH II, project procedures will be required subsequent to PEH II for projects for the different components (for example, a pipeline or power plant). For each project procedure, more detailed studies are carried out for the spatial plan and the required licenses based on, for example, a concrete route for a pipeline or a concrete location for a power plant.

Example of level of detail for the 'noise' sub-aspect and project procedure
In the IIA/SEA-r for PEH II, we assess noise using contours based on a reference installation for search areas for an electrolyser or power plant. In a project procedure, noise calculations are carried out for a concrete location and – if applicable – evaluated using the zone management model for industry and business parks.

4.3.3 Reference situation

The reference situation is the situation used to compare against when identifying the impacts on environment and space. The reference situation for PEH II is the current situation, including autonomous developments. Autonomous developments are developments that will occur independently of the proposed activity (PEH II). Plans and projects yet to be realised are counted as autonomous developments if the decision-making procedure has been completed or if it is anticipated that this procedure will have been completed before or in parallel to the decision-making for PEH II. For the impact assessment, we consider both developments up to 2050 (the horizon year for PEH II) and developments up to 2100.

4.3.4 Impact assessment at national system level

Different alternative scenarios will be drawn up for the whole national energy system in the IIA for PEH II, as described in Chapter 3. This will enable the impacts of the energy transition to be compared with other transitions at the system level, with the aim of shedding light on the main differences between the impacts of various system developments. For example, the difference between an energy system with a high degree of electrification and a system with a high level of hydrogen imports and the impacts on the water system. These impacts can be identified in PEH II and used as strategic decision-making information to inform choices about the energy mix in the National Energy System Plan (NPE). Giving more weight to the impact on the living environment when making choices about the energy system is one of the public interests of the NPE (see also the text box below).

Space as a pillar of the national energy system
The choices in the National Energy System Plan (NPE) are based on five public interests. When it comes to choices in the energy mix, the government aims for the highest societal value. Besides space & environment, the public interests are: affordability, security of supply, safety, sustainability and justice. The space & environment public interest is described in the National Energy Network Development Plan. A new NPE will be adopted in 2028.

4.3.4 Cumulation

Cumulation refers to the possibility of impacts reinforcing one another (in both the positive and negative sense); this is investigated in order to reveal the extent of (negative) impacts for different developments combined. Investigating cumulative impacts only makes sense for areas where different developments coincide, and if their developments and impacts are to some extent concrete. For this reason, they are only considered in research round 2. Following the impact assessment in round 2, we will have the most concrete information about locations, areas and strips (for line infrastructure). We will focus on locations where there are multiple developments relating to energy infrastructure. It is also desirable to shed light on the sum of impacts for each theme. This helps translate the impacts of individual energy infrastructure components within a theme to a national picture.

4.3.5 Mitigating measures

Environmental impacts can be limited or prevented by taking mitigating measures. In the assessment in the IIA/SEA-r, potential mitigating measures are considered, along with their impact on the assessment. These may be measures in the form of spatial optimisation (for example, modifying the location), technical prerequisites or measures or a particular working method, such as the period of works. In view of the level of detail of the assessment of such a broad programme at national scale, an assessment is made of the opportunities for mitigation.

4.3.6 Knowledge gaps

When assessing impacts for the Environment & Space theme, it is possible that not all the information required for the decision-making within PEH II will be available. This is known as a knowledge gap. Knowledge gaps which are relevant for the decision-making are identified in the assessment. In addition, an explanation is provided of how the knowledge gap can be resolved and whether this can be achieved in follow-up procedures or if more wide-ranging research is required.

4.3.7 Appropriate Assessment

If the proposed policy and the activities in a programme, such as PEH II, may lead to significant negative consequences for Natura 2000 areas, an Appropriate Assessment must be drawn up for the programme[25]. The Appropriate Assessment corresponds to the level of detail and the decision-making of PEH II (Appropriate Assessment plan).

4.4 Well-being assessment methodology

Within the ‘Well-being’ theme, an assessment is made of the (broad) societal impact of possible developments of the energy system. The assessment consists of three components: direct costs, national welfare and regional spin-off.

4.4.1 Direct costs

Within the ‘direct costs’ component, the direct infrastructure costs of the spatial and energetic scenario variants (see section 3.3) are assessed. The spatial scenario variants consider, among other things, the impact of different locations of batteries and landfall sites (in combination with nuclear power plants) on the direct costs. The energetic scenario variants consider, among other things, the impact of different quantities of batteries and electrolysis/hydrogen storage. The analysis includes the investment and operational costs of required upgrades, but also the possible consequences of failing to achieve those expansions in time (including redispatch costs).

The assessment is based on cost estimates by grid operators and supplemented with cost coefficients where necessary.

[25] *Article 16.53c of the Environment and Planning Act.*

4.4.2 National welfare

The ‘national welfare’ component is assessed using the societal cost-benefit analysis (SCBA) methodology. The welfare (well-being) analysis is conducted in the form of a ‘mini SCBA’ or quick scan; this means that the most important impacts are considered, to the extent that they make a difference to the strategic choices.

The impacts within the analysis – as is usual within an SCBA – are determined at national level and comprise both the priced impacts (including the direct costs described in 4.4.1) and the unpriced impacts (such as impacts on people, environment and space). As far as possible, the impacts are expressed in euros: where that is not possible, they are expressed qualitatively. The overview of costs and benefits derived from the analysis explicitly aligns with the themes and indicators from the Monitor of Well-being published by Statistics Netherlands.

4.4.3 Regional spin-off

Alongside costs and benefits for society as a whole, benefits for the regional economy (spin-off effects) are also identified. Where in the Netherlands will the economic impacts of investments in the national energy network be felt? How much will leak away abroad and how much will benefit the regional economy? This relates to both direct and indirect economic impacts (in euros) and employment impacts.

4.5 Feasibility assessment methodology

The ‘feasibility’ theme relates to the feasibility of the programme, both for the public authorities involved and for the grid operators and market operators that will carry out the actual implementation. The ‘feasibility’ theme considers three aspects of implementation:

- Location and time
- Areas of overlap and opportunities for linkages between different policy domains
- Prerequisite instruments (the aspects are explained below).

The research results in an overview of the most important implementation aspects for each development of the energy infrastructure.

Location and time

Spatial limits and constraints on realising energy infrastructure in timely fashion are considered under the ‘location and time’ implementation aspect. After all, not everything can be built everywhere at the same time: what can go together where, what cannot and where are choices needed? Matching the time required for the realisation of planned energy infrastructure with consumption plays a major role in the time aspect.

Areas of overlap and opportunities for linkages

Energy is increasingly becoming an integral part of policy development in an area. Policy challenges, such as making energy supplies more sustainable, large-scale housebuilding or upgrades to defence facilities, that have a major impact on the energy system need to be coordinated ahead of time. By identifying areas of overlap, integrated choices can be made and opportunities for linkages utilised.

Prerequisite instruments

Some components of the energy system that require a lot of space will largely depend for their feasibility on prerequisite instruments. For example, PEH I stipulates that pipeline zones should have sufficient capacity for the new energy system and the transport of hazardous substances, but during the IIA it was noted that this would require tightening of oversight and enforcement to prevent conflicting spatial developments.

4.6 Integrated Impact Analysis: main report

The assessment of the different themes is presented in background reports. The summary and conclusions of those background reports are incorporated into a main report. An integrated analysis is achieved by bringing together and linking together the outcomes of the different themes in the main report.