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Collision effects of North Sea wind turbines on bird species within the "Kader Ecologie & Cumulatie (KEC) 5.0. Actualisation of models, data and predicted mortality for Dutch offshore wind development scenarios. G.J. IJntema, N. Heida, J.J. Leemans, A. Gyimesi, A. Potiek, 2025

Population level effects of displacement of marine birds due to offshore wind energy developments, KEC 5. F.H. Soudijn, M. Poot, V. Hin, C. Chen, E. Melis, D. Benden, 2025

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Knowledge update KEC5 density maps seabirds. S. van Donk, 2024.

1 Introduction

1.1 Background

There has been a need to describe and assess the effects of human activities on natural ecosystems since at least the 1970s. In the 1980s it was realised that it is not enough to describe and assess the effects of specific proposals and activities, but that it is also necessary to examine whether the effects of various different activities can accumulate to produce larger or more damaging ecological or environmental impacts.
Despite the difficulties, the importance of properly describing and addressing the issue of cumulative effects was acknowledged and incorporated in nature conservation legislation.

That legislation stipulates that ecological values, in terms of natural habitat types, species habitats and species, should be protected not only from the possible adverse effects of each separate human activity but also from the cumulative effects of all human activities.

In the Netherlands the European Habitats and Bird Directives have been implemented in the Nature Conservation Act, which has in turn been implemented in the Environment and Planning Act since 1 January 2024. The regulation for nature protection has been implemented in the underlying Activities in the Living Environment Decree (the BAL).
The Environment and Planning Act also takes cumulative effects into account in the provisions relating to species.

Since 2005, the Dutch government has received development consent applications for offshore wind farms that require a decision about how to assess not only the effects on the marine ecosystem of the separate wind farms but also the cumulative effects associated with other wind farms and in combination with other activities. Given a number of issues, including knowledge gaps about the cause-effect relationships, the presence of marine species and the resulting mandatory application of the precautionary principle, the assessment led to the imposition of restrictions on the development of offshore wind power and to a number of mitigation measures.

On the basis of the knowledge gaps that have been identified, research programmes have been established (in the Netherlands, for example, the Offshore Wind Energy Ecological Programme (Wozep)). Other countries have also acknowledged the problem of identifying and assessing the effects (cumulative and otherwise) of offshore wind farms and have completed extensive research in recent years.

1.2 Offshore wind energy in the Netherlands

To achieve the aims of the Climate Agreement from late 2015, the Netherlands originally proposed the production of 49 terawatt hours (TWh) of offshore wind energy per year by 2030. This goal would have required a capacity of 11.5 gigawatts. In 2022, the cabinet decided to increase the target to approx. 21 gigawatts in 2030 (later adjusted to 2032/2033). The Roadmap for Offshore Wind Energy 21GW (the former 2032 Roadmap) sketch an outline for the development of the new wind farm areas required.

Energy Agreement
The 2013 Energy Agreement on sustainable growth stated that, by 2023, offshore wind farms would have a total capacity of around 4.5 GW. Subsequently, in 2015,

the Dutch Offshore Wind Energy Act came into effect. This Act allows the government to designate areas for the development of offshore wind farms.

Roadmaps
The first roadmap for offshore wind farms (up to 2023) was used to designate sites in the Borssele and Hollandse Kust (South and North) wind farm areas.
The 2030 roadmap sketches the outlines for the creation of additional capacity amounting to around 7 GW of offshore wind energy in the 2024-2030 period.
The aim of a reduction in carbon emissions of 55% by 2030 compared with 1990 was set in 2020. It was therefore decided in 2022 to create a total capacity of approximately 21 GW of offshore wind energy by 2030 (adjusted later to 2032) in order to comply with that target.

This roadmap (Offshore Wind Energy Roadmap 21 GW) is the offshore wind farm scenario covered by this KEC 5.0.

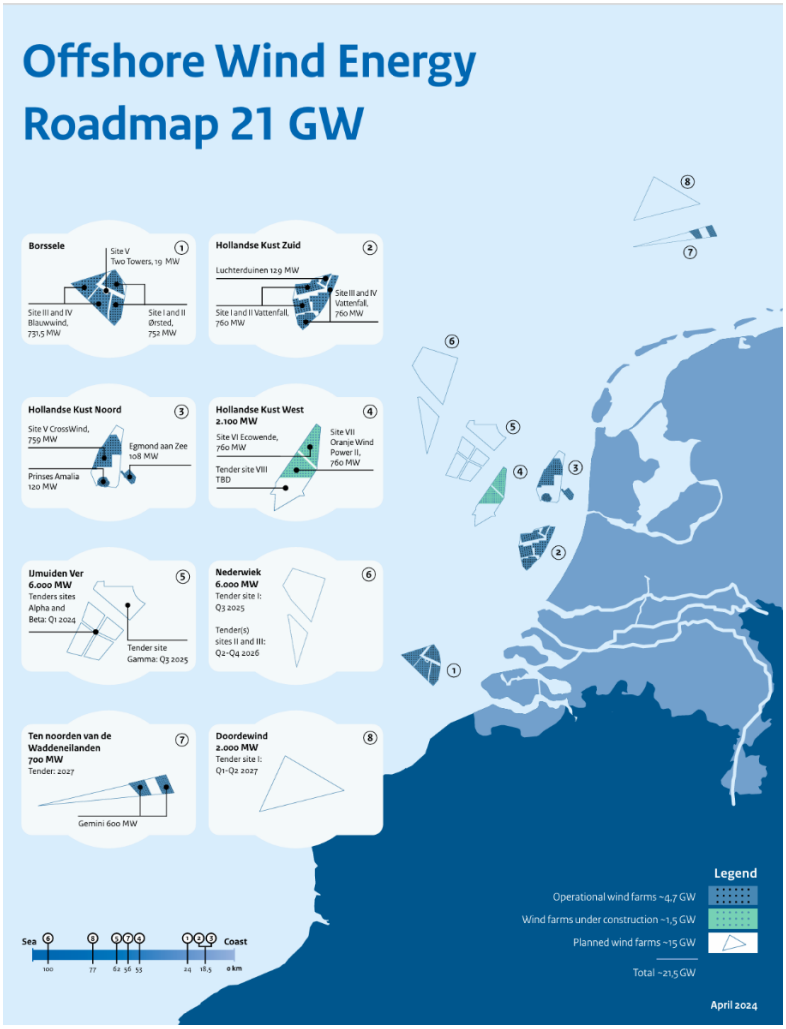

Figure 1 Updated Wind Farm Zones on the Dutch Continental Shelf (DCS) in the period 2016-2032, from Parliamentary Letter dated 25 April 2024. Subject: Update of supplementary roadmap for offshore wind. These wind farms have been included in the national scenario. An average permit duration of 35-40 years after the farm goes operational has been assumed.

	(Estimated) Operational year	Total installed capacity[MW]	Installed capacity per wind turbine [MW]	Number of turbines
Prinses Amalia Windparken (PAWP)	2008	120	2	60
Offshore windpark Egmond aan Zee (OWEZ)	2007	108	3	36
Luchterduinen	2015	129	3	43
Gemini	2017	600	4	150
Borssele I and II	2020	752	8	94
Borssele III and IV	2021	731	9,5	77
Borssele V	2021	19	9,5	2
Hollandse Kust (zuid) I and II	2023	770	11	70
Hollandse Kust (zuid) III and IV	2023	759	11	69
Hollandse Kust (noord) V	2023	759	11	69
Hollandse Kust (west) VI	2026	756	15	54
Hollandse Kust (west) VII	2027	840	15	60
IJmuiden Ver Alpha	2029	2010	15	134
IJmuiden Ver Beta	2029	2010	15	134
IJmuiden Ver Gamma	2031	2295	15	153
Nederwiek (zuid) I	2030	2295	15	153
Ten Noorden van de Waddeneilanden *	2033	795	15	53
Nederwiek (noord) II	2032	2295	15	153
Nederwiek (noord) III	2031	2295	15	153
Hollandse Kust West VIII	2032	760	20	38
Doordewind I	2032	2300	20	115

** Ten Noorden van de Waddeneilanden wind farm, although operational in 2033, has been included in the scenario.*

1.3 Benefits of using the Framework for Assessing Ecological and Cumulative Effects

The mapping of cumulative effects is an intrinsically complex issue that may, in principle, include the consideration of large numbers of species, relevant initiatives and effects.
Sometimes one type of effect is not harmful to protected species or habitats. However, in combination with other effects, that may be the case. These effects may be the result of the same activity or of other activities.

This KEC was developed to understand the cumulative effects of wind farms better. It shows how species, populations and effects can be included in the assessment of cumulative effects of offshore wind and how these effects should be identified, described and modelled. It also states whether mitigation measures are required to reduce the effects.

The KEC provides an overview of the latest knowledge and methods for calculating cumulation.

A Cumulative Effects Analysis (CEA) combines the effects of different activities at a higher level of abstraction and looks (often qualitatively) at environmental effects.

However, it can also look at, for example, physical effects or socioeconomic effects. By contrast, the KEC looks solely at the effects of wind farms on protected species and makes quantitative calculations using mechanistic models to determine effects at the population level. Nevertheless, the KEC calculations can be used as part of a CEA.
The framework and the calculations can be used to check in an ecological way beforehand whether the planned wind farms will comply with the ecologically acceptable levels in the future without significant negative effects. This means that unexpected negative ecological effects can be prevented, such as the final wind farm in the road map proving to exceed the applicable ecological limits.
Calculating the cumulative effects of a roadmap at an early stage makes it possible to take steps in good time if there are major negative effects.
If the planned wind farms do not fit within acceptable levels, additional analyses with regards to the legal conservation status will be required.
If a roadmap with wind farms exceeds the ecologically acceptable limits, this may be because there are knowledge gaps and that worst-case assumptions have therefore been made for precautionary reasons. Developing knowledge can allow for the adjustment of worst-case assumptions to more realistic assumptions and reduce the potential effects.
It may also be the case that the wind farms will have additional negative effects on specific species. The cumulative calculations from the KEC can determine which species are 'critical'. Nature-enhancing measures can then be taken for those species.
The KEC calculations also provide an insight into whether mitigation measures are necessary. For instance, in the case of underwater noise from piling, the mitigation measures for noise reduction can be spread across multiple wind farms so that the financial and technical burden of the mitigation measures is also shared. Equally, it is possible to determine at an early stage whether mitigation measures should be developed: there is then still time to research mitigation measures. Finally, steps can be taken in the policy area to decide whether there are opportunities to mitigate negative effects in other ways, to reduce pressure from other sectors, or to see whether other political decisions are possible.

1.4 KEC as a living instrument

Rijkswaterstaat (part of the Ministry of Infrastructure and Water Management) developed the Framework for Assessing Ecological and Cumulative Effects (KEC) for Wozep (the Dutch national Offshore Wind Ecological Programme, see Wozep ecological programme - Noordzeeloket UK), with assistance from an interdepartmental steering group of representatives from various departments of the Ministry of Climate Policy and Green Growth, the Ministry of Agriculture, Fisheries, Food Security and Nature, and the Ministry of Infrastructure and Water Management. The KEC was designed to be a living instrument and so it is regularly updated in line with new scientific knowledge of importance regarding the ecological themes in the framework, or new policy decisions regarding marine spatial planning developments on the North Sea, such as developments in the rollout of offshore wind farms.

History and development of the framework
The origins of the KEC Framework go back to 2015. Rijkswaterstaat conducted two impact studies for use in the drafting of the first version of the framework (version 1.1, 2015) and an update (version 2.0, 2016) (Platteeuw et al., 2017). The KEC 3.0 (2019) was then completed for the 2030 Roadmap, followed by the KEC 4.0 (2022) for the wind farm areas described in the 2022-2027 North Sea Programme. The present KEC (5.0) has been drawn up for the Roadmap 21 GW.

Annex 2 shows the differences between KEC 1.1 & KEC 2.0, KEC 3.0, KEC 4.0 and KEC 5.0.

In addition to the new scenarios for wind farms, both national and international, new knowledge has been developed in the period between the first KEC calculations (2015) and the KEC 5.0, for example in the Wozep programme.
Updates/amendments were required in the KEC given changes in the insights in terms of knowledge. An up-to-date knowledge base is required at any given moment but particularly when important policy decisions have to be considered, discussed and made. This consideration may also provide directions for timely knowledge building through research.

The KEC is adopted by the Ministries of Agriculture, Fisheries, Food Security and Nature; Infrastructure and Water Management; and Climate Policy and Green Growth via the Wozep Steering group. After adoption, it is published on the Noordzeeloket.nl website (Framework for Assessing Ecological and Cumulative Effects - Noordzeeloket UK).

Future developments towards the KEC 6.0
After the KEC 5.0, the knowledge gaps and further areas requiring development in the models and methodologies identified during the drafting of the KEC 5.0 will be examined in more detail and, if possible, elaborated upon. Based on the precautionary principle, worst-case assumptions are maintained for knowledge gaps involving major uncertainties as long as those uncertainties remain. Research can serve to reduce these uncertainties.
Research to address the knowledge gaps, and to develop the models and methodologies further, will be implemented in the next knowledge base update, which will then be used for the KEC 6.0. The aim is to publish the KEC 6.0 in 2026/2027.

Strategic impact analysis
At the time of working on the KEC 4.0 it became clear that the KEC method with detailed calculations is less suitable for strategic plans extending further in the future (such as the Partial Revision of the North Sea Programme) because of its quantitative complexity. This is because those strategic plans are more abstract and have a more distant time horizon. The KEC methodology requires more detailed information than is available at the outset of a strategic assessment.

The KEC methodology needs quite detailed information such as wind-farm data (such as rotor length and nacelle height) and, more importantly, ecological parameters like population sizes and trends. A large time interval between the current situation and the strategic plan horizon is not acceptable. Expert opinion indicates that this interval is between six and ten years based on the six-year cycle for N2000 and the MSFD.
Using the KEC methodology in the strategic assessment phase precludes the use of future innovations (technical and ecological/mitigation) and new knowledge.

The VECI (Exploration of ecological cumulative impact) was therefore developed for strategic assessments (or assessments at a more abstract level). It covers the same elements as the KEC but in a qualitative manner without in-depth calculations.
The VECI for the longer-term scenarios is a more qualitative approach, providing an estimate of the ecological impact in scenarios based on current knowledge.

The VECI produces insights into future ecological impacts, and knowledge gaps relating to these ecological impacts. Because a picture of the knowledge gaps is established at an early stage, it is possible to engage in research in good time in order to remedy these knowledge gaps. In addition, an overview of the nature restoration required can be provided early and that work can start. Furthermore, mitigation measures can be researched and potential policy decisions can be made.

1.5 Structure of KEC 5.0

The KEC consist of three building blocks and a separate ecological threshold component:

1) A *Conceptual Framework (Part A)* describing the conceptual framework for addressing ecology and accumulation, scope, prerequisites, and some more generic topics.
2) A *Substantive knowledge base (Part B, KEC instruments)* containing the most recent scientific knowledge, substantive methodologies and models used. There is a specific update for the knowledge base for each report (for example about underwater noise, habitat loss, collisions and ecosystem effects).
3) *Calculations (Part B, KEC calculations)* describing the OWF scenario to be calculated, the calculations themselves, the tests applied to the thresholds and the potential options for mitigation. Specific calculations are made for each report (for example about underwater noise, habitat loss, collisions and ecosystem effects).

The building blocks and the ecological threshold component will be discussed in further detail in Chapter 2.
Building blocks 2 & 3 have been combined in the substantive reports (Part B reports). These reports provide further details about the changes with regard to the calculations in the KEC 5.0.

Part B reports
KEC 5.0

- Impact of offshore wind farms on the North Sea ecosystem. Scenario study for the partial revision of the Dutch offshore wind planning. Zijl et al, 2024.
- Collision effects of North Sea wind turbines on bird species within the Kader Ecologie & Cumulatie (KEC) 5.0. Actualisation of models, data and predicted mortality for Dutch offshore wind development scenarios. G.J. IJntema, N. Heida, J.J. Leemans, A. Gyimesi, A. Potiek, 2025
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- Marine Strategy Framework Directive descriptors in relation to OWFs and Framework for Assessing Ecological and Cumulative Effects (KEC 5.0). M. Verdonk (RWS), M. Graafland (RWS), Q. Schürmann (WE), D. Barbé (WE), 2025.

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- Letter report Changes in Harbour porpoise distribution in the North Sea. Reference 2424737.SG.mb. S. Geelhoed, 2024.

- Knowledge update KEC5 density maps seabirds. S. van Donk, 2024.

The report on ecosystem effects (Zijl et al., 2024) has been drawn up on the basis of both the KEC 5.0 and the Partial Revision of the North Sea Programme. The Partial Revision of the North Sea Programme addresses the period after the KEC 5.0 planning period. In the report on ecosystem effects, the KEC 5.0 scenario will be referred to as the 'Baseline scenario' throughout the report. The analyses for the Partial Revision were primarily conducted with respect to the Baseline scenario. The chapters in the ecosystem report that focus more generally on the study or specifically on the KEC 5.0 are:

- Chapter 1
- Chapter 2, 2.2
- Chapter 3 , 3.1, 3.2.1, 3.2.2, 3.2.3, 3.3
- Chapter 4, 4.1
- Chapter 5, 5.1, 5.2, 5.6
- Chapter 6, 6.1, 6.2, 6.5
- Chapter 7, 7.1, 7.2
- Chapter 8
- Annexes A, B, C

1.6 Document structure

The KEC building blocks are listed in Chapter 2.
Chapter 3 describes the legal framework.
Chapter 4 outlines what the KEC can be used for, and what is and is not included in the KEC. It also provides a rationale for certain decisions regarding the scope of the KEC. Chapter 5 describes the generic approach for identifying and describing cumulative effects and how this is done for offshore wind energy. The factors that need to be considered are identified in a step-by-step process.
Chapter 6 examines the assumptions used for the scenarios and assessments.
Finally, Chapter 7 provides an overview of the knowledge gaps.

2. KEC building blocks

2.1 The KEC Building Blocks

The KEC can be divided into three building blocks and a separate threshold component:

1) Conceptual Framework;
2) Knowledge base update, the KEC instruments;
3) Calculations, the KEC calculations.

In addition to these three building blocks, the outcomes are also tested on the basis of ecological thresholds (4). The drafting and adoption of these thresholds is an important final step but not a part of the actual KEC methodology.
The thresholds are determined by the Ministry of Agriculture, Fisheries, Food Security and Nature (LVVN). The calculations in building block 3 are tested on the basis of these thresholds.

1) Conceptual Framework
The moment there are changes from the perspective of politics, legislation and regulations, international cooperation or scope, changes will be required in the conceptual framework.

2) Substantive knowledge base, KEC instruments
Periodical checks (which are intended to be conducted annually) can then be made to determine whether there are reasons to adjust the substantive knowledge base on the basis of significant new knowledge (Wozep research, other ecological research, national, international).
The knowledge base includes:

- the latest scientific insights from either targeted Dutch research in Wozep and MONS or from science in general. This includes model parameters and knowledge about dose-response relationships.
- the models used (numerical and otherwise), which are a record of scientific knowledge. Version management is essential in the context of knowledge management.

In addition to the knowledge base, there is also a data and information base. Types of information include:

- scatter maps of various types, density maps, etc.
- descriptions of scenarios describing which wind farms to include or not and assumptions about the wind farms
- metadata about models (version management)
- good description of the total KEC process (with diagrams and data flows)
- oceanographic and meteorological data

These data can be obtained from Wozep (Wozep research programme - Noordzeeloket UK).

The above is not a restrictive list and it is subject to change over time. New insights about specific effects on species that have not yet been previously identified and/or new population models with different model parameters can also lead to new research from which new knowledge can emerge. A revision of the species list, for example, can also generate new knowledge and data. If a new species is considered in the KEC calculations, for example, species-specific population models will be needed.

3) KEC calculations
The calculations can be regarded as a stand-alone module with one or more scenarios as input.

If there is a new roadmap for OWF development or an extension or shift of the scope, significant new knowledge or new thresholds, then calculations will be required for this new situation.

4) Thresholds
The Ministry of Agriculture, Fisheries, Food Security and Nature (LVVN) is primarily responsible for the thresholds and for keeping them up-to-date. The thresholds are based on the current conservation status and international status. If there is new knowledge about population size, regeneration time, conservation status or international status, the thresholds can be revised. The thresholds should be determined at least every six years by LVVN in conjunction with the periodic assessments under the Birds and Habitats Directives. Thresholds may also be altered in the interim if there is good reason to do so. Information about the thresholds used can be found in Annex 4.

If a more optimal KEC instruments approach or an approach with new insights are required, these three building blocks could each be tackled separately and kept up-to-date. Overarching data, information and knowledge management are in place to safeguard the continuity and traceability of the results of KEC calculations. A new KEC calculation can therefore be tackled quickly and efficiently as a process.

The three building blocks are closely linked. If the scope is modified, the conceptual framework (part 1) will have to be amended as well. As soon as there is significant new knowledge (to be included in part 2), new calculations may be required if it is expected that the new knowledge can lead to an effect on the calculation(s) performed earlier. If a new threshold is established, a run/execution of the calculations (building block 3) will always be needed.

3 Legal Framework

The legal framework is not fully covered by the KEC instruments and KEC calculations. Chapter 4 will elaborate on this.
Much of the relevant national and international legislation for assessing effects on the physical environment has been incorporated in the Environment and Planning Act (affective 1 January 2024). This act replaces a number of separate laws and regulations, including the Nature Conservation Act.
The Offshore Wind Energy Act, which covers offshore wind farms, has not been housed with the Environment and Planning Act. However, the Site Decisions pursuant to the Offshore Wind Energy Act must comply with the nature protection objectives stated in the Environment and Planning Act. In addition, compliance is required with international legislation and regulations such as the Marine Strategy Framework Directive (MSFD), the aim of which is to protect or restore generic ecosystem qualities, or specific habitats and species.

Offshore Wind Energy Act
Pursuant to Article 3(1) of the Offshore Wind Energy Act, the Minister of Climate and Green Growth can make a site decision in consultation with other relevant Ministers. A site decision designates a site for a wind farm and the connection between the wind farm and the offshore grid.
An important part of the site decision with regard to the ecological impact is the assessment of nature. The integrated implementation of the assessment of nature is further elaborated in Articles 5 and 7 of the Offshore Wind Energy Act: no separate environmental permit for flora and fauna activities or Natura 2000 activities is required under the Environment and Planning Act.

Environment and Planning Act – Nature protection
The Environment and Planning Act protecting natural values and biological diversity came into effect on 1 January 2024. This act incorporates all the legislation for the living environment, including the Nature Conservation Act.
The rules from the old nature legislation have been adopted in the Environment and Planning Act and the Environmental Activities Decree of the Environment and Planning Act. The protection regime for species and prohibitions has not changed as a result. Assessment on the basis of Natura2000 objectives and Dutch Conservation Status has remained unchanged.

Marine Strategy Framework Directive (MSFD)
The Marine Strategy Framework Directive (Directive 2008/56/EC of the European Parliament and of the Council) obliges Member States to take the necessary measures to protect and restore the Good Environmental Status (GES) of the North Sea and to ensure sustainable use. Good Environmental Status is assessed on the basis of eleven descriptors.

ASCOBANS
In the context of the ASCOBANS Treaty (Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas), an interim target has been set stating that a population may not fall below 80% of the carrying capacity level. See Annex 4 for more information about this threshold.

4. Scope and use of the Framework for Assessing Ecological and Cumulative Effects

4.1 The scope of the Framework for Assessing Ecological and Cumulative Effects

Intended Users

The framework was drafted primarily for use by all government departments and agencies involved in decision-making relating to offshore wind energy, such as site decisions. The framework provides transparent information on how the cumulative effects of offshore wind energy should be identified and assessed, which methodologies and knowledge are most recent, and which uncertainties and knowledge gaps remain. It is therefore also relevant for external parties that draft EIAs (Environmental Impact Assessments) for offshore wind energy, for stakeholders in offshore wind energy and for non-governmental organizations (NGOs). In addition, the calculations indicate beforehand whether the planned wind farms will comply with the ecological acceptable levels or not. This allows government departments and researchers to take timely action and, for example, to study particular species or mitigation measures, to take measures to strengthen nature for the species in question, or to make political decisions (see Section 1.3).

Scope

The KEC has been produced specifically for offshore wind energy. It considers only the known impacts from offshore wind development on specific species that could lead to significant adverse consequences. In the case of some effects, it is not known how and in what extent these effects affect certain species, those effects are not included in this KEC. For example, the effects of collisions on birds are included but not the effects of light disturbance or disturbance by shipping. There are also knowledge gaps relating to the effects that are covered in the KEC, and assumptions are most of the time based on science. For pragmatic reasons, other activities are not included in the KEC. This would actually be required for a full cumulative assessment. Other activities are not included in the KEC calculations because there are still many knowledge gaps here, and this would make the calculations of the effects less quantitative. The decision to limit the scope of the KEC to offshore wind was made by the Wozep/KEC Steering group. The full cumulative impact assessment should be included in the EIA.

Calculations are based on a scenario that includes all the national and international wind farms that are expected to be built in a defined period.

It has also been decided for pragmatic reasons not to include wind farms on the coast or onshore. If the total habitat of certain species is considered (the entire habitat including the breeding grounds), it would seem logical to at least include coastal wind farms in the cumulative assessments. These windfarms will be included in the legal assesment of the Conservation Status. This could be further elaborated for a subsequent KEC and will be decided by the Wozep/KEC Steering Group (2015).

In addition, calculations have not been made for all species. On the basis of the KEC, protected species only are considered. Not all protected species are considered, because previous KECs (see Annex 3) have shown that certain species were not present in the study area or that the wind farms had little or no impact. These assumptions will continue to stand until there are new insights. The species list will be reviewed periodically.

4.2 Underlying principles

The description of effects in the KEC 5.0 are based on the most recent publicly available scientific knowledge and the following underlying principles:

- transparency about knowledge gaps and assumptions;
- excluding uncertainties by applying the precautionary principle in a realistic worst-case approach,
- assumptions, such as assumptions about innovations, are on the conservative side;
- clarity about the geographical scale and time horizon of the calculated effects: assessing effects on the Dutch Continental Shelf scale and biogeographical scales;
- use of substantiated expert judgements to address knowledge gaps;
- an emphasis on possible adverse effects;
- only for those species that for which significant negative effects cannot be excluded beforehand.
- assessing effects on the conservation status instead of at the scale of one or more individual Natura 2000 sites
- including transboundary effects;
- including the wind farms and wind farm areas as far as known, even if permits have not yet been granted for those farms, in this case those which are expected to be built in the period leading up to 2032;
- including foreign offshore wind farms which are expected to be built in the period leading up to 2032.

4.3 The KEC calculations in relation to the legal framework

The KEC calculations are not a complete legal assessment. In some areas, the KEC goes beyond what the law requires; in others, the KEC is more limited than required by law.
In the following areas, there is a difference between what is required by law and what is covered by the KEC:

N2000 areas
In the Netherlands, the Environment and Planning Act implements the Birds and Habitats Directives through the designation and subsequent explicit protection of the Natura 2000 sites.
The KEC calculations involve an assessment at the population level rather than a review of the impacts for each Natura-2000 area. The idea behind this is that, if a particular species is not doing well at the population level, it will not do well in the N2000 areas for that particular species either
This approach was adopted because the natural functioning of the North Sea ecosystem is characterised by considerable variation in the spatial and temporal distribution of species. In addition, many species are highly mobile and not confined to the Natura 2000 network of protected areas. They include marine mammals and seabirds but also some larger fish species (such as sharks and rays).
Furthermore, the distribution of species varies considerably within and between seasons and years, and the best available knowledge is inadequate in the case of many species to identify areas which fulfil a specific ecological function over any prolonged period of time.
The KEC therefore assesses the effects on the populations in the study area (DCS and international, see Section 6.2) and is not usable for assessing effects on Natura2000-area's.

The assessment of effects on N2000 areas has to be made in the project-specific EIAs and AAs (Environmental Impact Assessments and Appropriate Assessments).

Assessing on the basis of Dutch thresholds
The Environment and Planning Act applies only to activities on Dutch territory and the exclusive economic zone in the North Sea. However, species and their habitats are not confined by national borders. An assessment of whether an activity is

acceptable is therefore logically demarcated by the national borders of the Netherlands but it must also take into account the effects on protected species outside the Dutch Continental Shelf as far as practical considerations and scientific knowledge allow.

The assessment for the Dutch section of the North Sea can be tested on the basis of the Dutch ecological thresholds, which are derived from the Dutch Conservation Status and population trends of the species in question. The KEC calculations also consider the international North Sea. There are no international ecological thresholds that have been adopted by all North Sea countries. However, visualising the ecological effects of the international OWF scenario does provide an indication of the potential species at risk (see Section 4.4) and provides a perspective for an international approach to certain critical species.

Activities
Under the Environment and Planning Act, the scope of the activities that have to be taken into account for a cumulative assessment is wider than offshore wind energy alone.
In the case of offshore wind energy, new (licensed)activities such as oil and gas extraction, sand extraction and solar also have to be considered when determining the cumulative effects of a project. If the accumulation of different effects is considered, existing activities or developments in existing activities, such as fisheries and shipping, must be included. At present, the KEC looks only at activities related to offshore wind energy.

Scenario: which wind farms should be considered in terms of time and space
The KEC calculations take all offshore wind farms (realised, licensed and planned/foreseen in a Roadmap) into consideration to determine the cumulative effects in comparison with a situation without wind farms. Under Article 6(3) of the Environment and Planning Act, only *other plans or projects* have to be included in a cumulative calculation.
These are activities that will certainly be licensed but that have not yet been realized. In addition, ongoing activities do not have to be included if it can be assumed that certain effects of offshore wind farms can be discounted in a population.
The KEC calculations do take planned/foreseen wind farms and those that have already been built into consideration because there is insufficient scientific knowledge and data about when certain effects from offshore wind farms can be considered in population calculations, and therefore about when they can be discounted in the effect calculations.
All these projects are therefore included in the KEC calculations as a precautionary approach, even though this could result in an overestimation of effects.

Because one of the aims of the KEC is to investigate whether an entire roadmap can be implemented without exceeding ecological thresholds in the future, proposed projects that have not yet reached the advanced planning stage are also included in the calculations. This is not required under the Environmental and Planning Act but it does provide valuable information (see Section 1.3).

Due to the practical limitations of the current models, the effects of wind farms in the scenario are calculated for forty years, regardless of when a specific wind farm is built or decommissioned. This may lead to an overestimation of the effects if, for example, a given wind farm is to be decommissioned soon and another wind farm

has yet to be built. A later KEC update will investigate the possible ways of including operational timeframes of specific windfarms in the scenario.

As mentioned in paragraph 4.1 KEC 5.0 looks at offshore wind farms only, not at wind farms on the coast. A later KEC update will investigate the possible ways of including coastal wind farms.

4.4 The KEC in relation to the EIAs and site decisions for offshore wind

As described in previous chapters, the KEC consists of three parts, two of which must be used in, for example, EIAs underpinning site decisions:

1. *The KEC instruments as a framework*: The KEC instruments are a mandatory set of methodologies, models, maps and knowledge. This complies with the description of the use of the KEC in, for example, the North Sea Programme. Accordingly, the most recent KEC instruments must be applied in EIAs, Appropriate Assessments etc. for offshore wind energy projects.
   The annual knowledge base update, with input from, for example, Wozep research, is part of this set of methodologies and instruments.

2. *KEC calculations leading*[1]*:* The KEC calculations determine the ecological effects of wind farms on certain species and assess whether the total impact stays below the thresholds/acceptable levels of impact (ALIs) set by the Ministry of LVVN. It should be noted that an EIA may make new data available (such as turbine specifications or other wind farm characteristics), or that there may be a new KEC knowledge base update making it possible that there will be an exceedance in the KEC but not yet in the EIA.

The KEC instruments are used to make cumulative effect calculations for the national and international scenarios in the roadmap by making comparisons between a scenario with wind farms and a scenario without. This calculation quantifies the reduction of a population by comparison with the scenario without wind farms, and assesses whether this population reduction is such that it exceeds the thresholds/ALIs.

Where the calculations show that the thresholds/ALIs are exceeded, the estimated impact exceeds the threshold for acceptable impact, which signals the urge for caution. The following actions can be taken:
- reducing uncertainties through research to get a better impression of the true impact
- proposing mitigation that can be included in the site decisions to reduce the impact of offshore wind farms
- including and implementing measures (other than mitigation) such as additional nature enhancement measures or species protection plans. However, although the KEC calculations can provide guidance with respect to this follow-up action, the KEC does not address this area.

On the basis of the results of the calculations (see Section 4.5) from the KEC, three areas need to be considered:

- The wind farm scenario consists of wind farms that have already been built, licensed or planned with, as far as is possible, realistic assumptions about the wind farms (numbers of turbines, height of the turbines, area off the

[1] Taking into account that the KEC does not yet provide a complete legal assessment framework.

wind farm etc). The realistic assumptions may differ from those in the actual site decisions since, for future wind farms, the assumptions are based on the precautionary principle and they therefore represent a realistic worst case. This implies that there may be a possible overestimation of effects. In the case of these worst-case assumptions, additional research will be conducted to produce more realistic assumptions.

- The national and international density maps used for bird species, on which the wind farm scenario is superimposed, differ. The density maps are the same nationally and internationally for harbour porpoises and seals. There is much more data for birds nationally (the MWTL database) than internationally (the ESAS database). In order to establish sufficiently robust international bird density maps, much longer time series are used for the international maps. The drawback is that the most recent developments in terms of numbers and distribution are less visible in the international maps.
- The ALI threshold values for birds are partly based on the Dutch Conservation Status (determined by the Ministry of LVVN), taking the international trend for birds into account to a certain extent. This means that the ALI thresholds are most suitable for testing the impact of the national scenario, and less so for the international scenario. The calculations for the national wind farm scenario indicate whether a planned roadmap complies with the ecological limits (see Soudijn et al., 2025 and Ijntema et al., 2025). In the case of the international scenario, monitoring compliance involves making a comparison between the pressure of the national scenario on the population by comparison with the pressure of the international scenario on the population.

In the comparison with the international scenario, there are four possibilities:

1. If, when the international and national effects are compared, there is *no ALI exceedance nationally*, and the *international effect is smaller or similar*, the international scenario is not a cause for concern.
2. Is there *no ALI exceedance nationally*, and the effect of the *international scenario is larger* than that of the national scenario, it cannot be ruled out that the international impact may be unacceptable.
3. If the *ALI is exceeded nationally*, and the *international effect is similar or larger*, the international effect is also a cause for concern and further analysis is required.
4. If, when *the national scenario results in an ALI exceedance,* the *international effect is smaller* than the national one, it is unclear whether the international impact is acceptable or not and further analysis is also required.

In situations 2, 3 and 4, the Netherlands may take action, for example by informing the relevant competent authorities of the countries concerned.

Although the ALI is not tested for the international scale due to thresholds being set for the Dutch situation, this signals that the impact of international wind farms (on the international population) may be unacceptable.
Any large effects from international wind farms may ultimately have an impact on the Dutch part of the biogeographical population.

4.5 The use of the KEC calculations

The previous chapter indicated that the KEC calculations sometimes include more factors than legally required, and sometimes fewer. This is confirmed by the legal analysis conducted by the Ministry of Agriculture, Fisheries, Food Safety and Nature (see Annex 2). Furthermore, the KEC calculations do not look at impacts on N2000 areas. The assessment based on the KEC is therefore not a substitute for the legal assessment in an EIA or Appropriate Assessment.

However, the results of the KEC calculations provide good insights into:

1. calculations for all the farms in the roadmap, with testing based on the ALI for the national situation, and an insight into whether or not the ALI is exceeded (this point is discussed in greater detail below); the international impact is compared with the national impact in order to give a general indication of the likelihood of exceeding the ALI for the international scenario.
2. which mitigation measures are required targeting the species that are running up against ecological limits (or almost doing so), and which measures could possibly be included in site decisions or researched;
3. clarity about uncertainties due to knowledge gaps as a result of which worst-case assumptions must be made. This can be used as a basis for decisions about research planning;
4. what is required from policymakers in areas such as planning, spatial planning or policy measures.

The roadmap calculations are based on the precautionary principle and they therefore work with worst-case assumptions.
If a scenario in the KEC assessment complies with the ecological limits (in other words, if there is no exceedance of the thresholds or ALIs), then it also complies with the legal framework of the Offshore Wind Act, on the understanding that an additional assessment must then be made that takes accumulation with other activities into account.

An assessment will also have to be conducted to determine whether the wind farm parameters used for the project in question fit in the wind farm parameters as included in the KEC scenario.

If a scenario in the KEC calculations does not comply with the ecological limits - in other words if a threshold value is exceeded, a further extensive examination will be required as part of the *legal* assessment of, for example, an EIA or Site Decision because the scenario calculated in the KEC goes beyond the legal scenario (see, for example, Annex 2). In an EIA examinations are always required, even if a scenario does comply.

Working with the ALI
The Acceptable Level of Impact (ALI, see Hin et al., 2024) is used for birds.
The ALI impact approach involves comparing the population of a given bird species over a period of forty years with and without wind farms. An assessment of an ALI exceedance considers only the relative difference in the modelled population size between the scenarios with and without wind farms, not the absolute size and relationship to the Conservation Status. In an ALI assessment, the final population size in the scenario with wind farms must not be more than X% below the final population size in the scenario without wind farms.

The ALI threshold established by the Ministry of Agriculture, Fisheries, Food Safety and Nature is based on the Dutch Conservation Status for a range of bird species, while keeping the national and international population trend in mind (SOVON, 2024). This threshold is, on the grounds of the precautionary principle, conservative so that, as long as the ALI is not exceeded, the probability of a population falling below the Conservation Status is small. However, the possibility cannot be completely ruled out.

When the ALI is used, the KEC calculations look at the impact of offshore wind energy on the population (ALI impact approach). An exceedance does not have a direct link to the relationship with the Conservation Status.
It is possible that there will be no exceedance of the ALI, even if the population is below the level of the Conservation Status, because it is also currently below the

Favourable Reference Value.[2] In that case, it can be stated that the exceedance of the Conservation Status is not attributable to the effects of offshore wind energy. Non-exceedance of the ALI indicates that the relative impact of offshore wind is limited.

On the other hand, the ALI may be exceeded while the population continues to grow in the scenario with wind farms and exceeds the level of the Conservation Status in the current situation (populationlevel is above the Favourable Reference Value). Ecologically, offshore wind energy does have an effect; legally, there is no exceedance of the Conservation Status.

If the ALI is exceeded, a further analysis will always be required of the effects of the wind farm in relation to the Conservation Status.
However, a more integrated assessment is then required of the effects of a wind farm over a period of forty years in relation to the Conservation Status, including an estimate of the effects of all other activities, the area of the suitable habitat, autonomous development and effects of, for example, bird flu during the next forty years.
At present, there is still no methodology available for a direct assessment of the Conservation Status (the ALI *status approach*). The possibility of developing a methodology of this kind will be considered in the run-up to the next KEC.

In summary, the KEC calculation can be used in the following way in the *legal* test in, for example, the EIA or Appropriate Assessment, see Figure 1.

In addition, the KEC does not look at individual N2000 areas; the assessment of N2000 objectives will have to take place elsewhere.

[2] The Favourable Reference Value (GRW) is a measure of the favourable ecological status of a species.

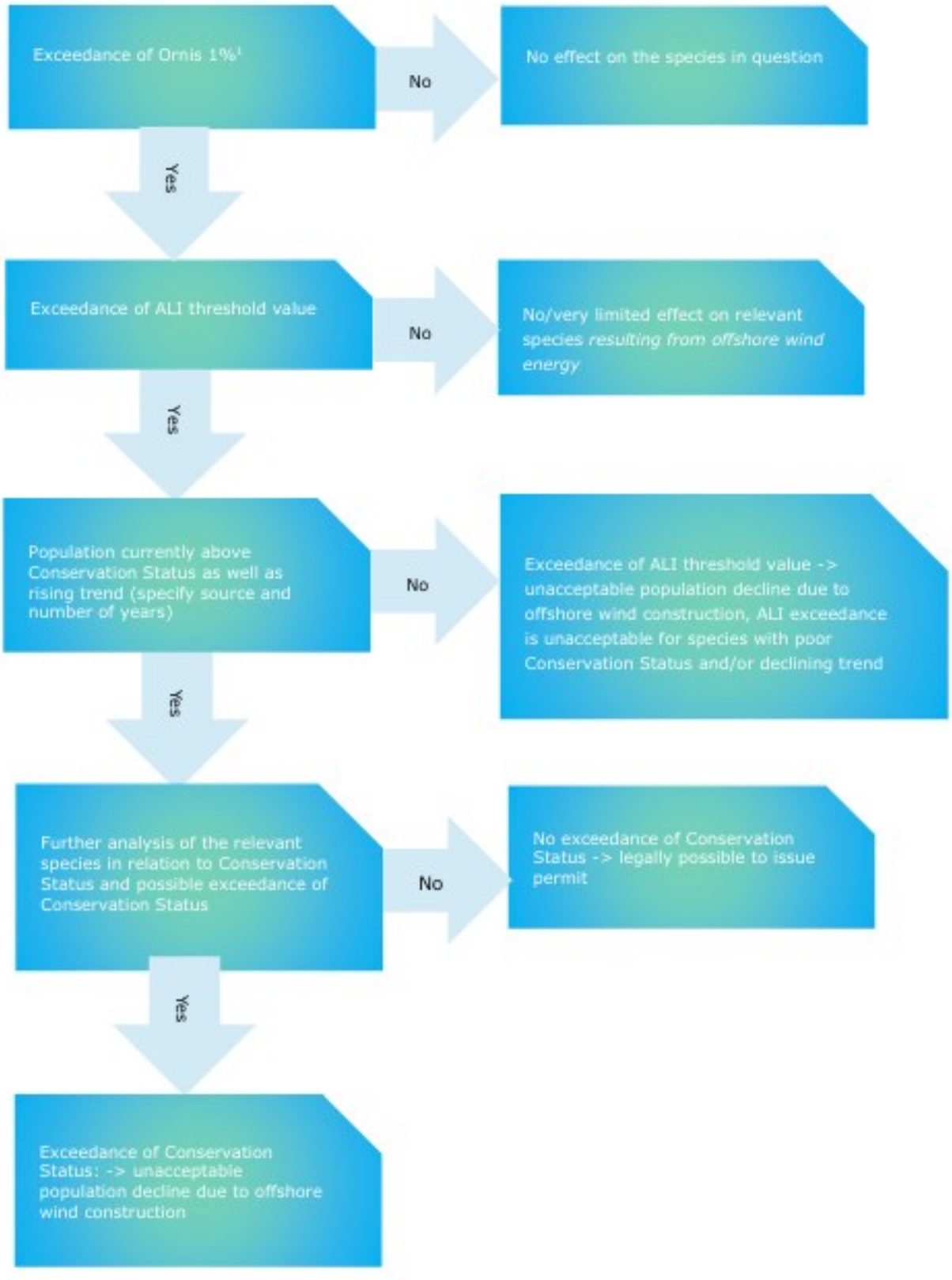


Figure 1. Example of the use of KEC calculations in legal test

5 The DPSIR method in relation to the KEC

This chapter describes the steps to be taken at the generic level to make an adequate assessment of the cumulative effects of proposed developments and how this is applied for the KEC. The corresponding sections in subsequent chapters examine these steps specifically for offshore wind farms.

The description and assessment of the cumulative effects of plans and projects in the KEC is a step-by-step procedure based on the DPSIR method. This method systematically identifies the drivers, pressures, state, impacts and responses in six steps (Platteeuw et al., 2017).
The first two steps are iterative and they are conducted simultaneously.

- Step 1: Identification of the relevant pressures the envisaged activity could cause (in this case, offshore wind farms only).
- Step 2: Identification of the habitats and species that may be affected by these pressures.
- Step 3: Description of all other pressures (resulting from both the same and from other drivers) that could affect the same species. In the case of the KEC, we look at the effects of offshore wind farms only. We therefore actually skip this step in the KEC. In that respect, the scope is more limited than is desirable with the DPSIR method.
- Step 4: Description of the nature and scale of the cumulative effects of all the activities selected in Step 3 on the selected habitats and species for the relevant[3] populations of those species (*impacts*). As stated, only activities related to wind farms are considered for the KEC.
- Step 5: Evaluation of the significance, by means of a comparison with the statutory conservation targets, of both the *state* (e.g. conservation objectives) and the *impact* (on ecosystem biodiversity, for example) of the effects on the selected habitats and species.
- Step 6: If necessary, adaptation of the activity through mitigation or compensatory measures (*response*) so that the activity does not contribute to any significant effects.

5.1 Identification of pressures from the activities to be assessed (Step 1)

The pressures from the activity (in other words, the installation, operation and decommissioning of offshore wind farms) to be assessed are described in conjunction with Step 2 and that description is dependent on the same step, viz. the identification of sensitive species and habitats. The activity to be assessed is the human activity that may have an impact on the species, habitats or other ecological values of prime concern for the assessment. The pressures are those aspects of the activities that may cause impacts.
Examples of pressures are disturbance caused by mechanical activities and obstacles, disturbance caused by light, habitat loss and shifts in ecosystem functioning.

Pressures are relevant only if there are species and/or habitats sensitive to them in the area (including the vicinity that may be affected as well). Identifying the pressures starts with a detailed description of the proposed activity, its physical characteristics, dimensions and duration for all phases: preparation, construction, operation, and decommissioning and removal.

Different activities occur during each of these phases (for offshore wind farms: shipping movements, excavation, construction, operations and maintenance, and

[3] In this context, the 'relevant' population is understood to mean the population of the total geographical area in which the intended activity will take place.

finally decommissioning) and these activities exert different pressures. The spatial dimensions of these pressures must then be identified and this cannot be seen in isolation from the sensitivity of habitats or species. For example, if a species is affected by noise above a certain level, the spatial dimension of this pressure is the area within which the noise is louder than the maximum level acceptable in the case of the species concerned. The level of detail required when identifying and describing the pressures must be determined in conjunction with Step 2.

The relevant pressures from the construction phase, the operational phase and the decommissioning phase of the wind farms are listed below. This is a provisional list because new knowledge and new insights, and changes in species composition, for example as a result of climate change, may result in the amendment of this list.

The main pressure in the construction phase is underwater noise resulting from piling work for the foundations. The following pressures are also relevant in this phase:

- disturbance caused by mechanical activities such as vibration and noise;
- attraction to and disturbance caused by light;
- disturbance resulting from the clearance of unexploded ordnance;
- disturbance caused by intensive shipping activity during construction;
- disturbance caused by the depositing of material (for scour protection).

In the operational phase, it is primarily the wind turbines themselves and the total marine area taken up by the wind farms that can have adverse effects on animals. The following pressures are relevant in this phase:

- habitat loss, possibly resulting in habitat fragmentation;
- disturbance of the migration routes of birds and bats;
- vibrations and noise;
- attraction to and disturbance caused by light (lighting);
- disturbance caused by maintenance vessels;
- contamination caused by the release of substances such as anti-corrosion and antifouling products;
- changes in hydromorphological processes (such as currents and sedimentation);
- death or injury caused, for example, by collisions or near-collisions with turbines;
- changes in species composition and food availability or competition for food resulting from the introduction of new habitats (hard substrate) such as foundation piles and riprap around piles;
- effects of certain uses in wind farms (such as certain types of fishing);
- electromagnetic fields generated by cables.

In the decommissioning phase, the most important pressure is again most likely to be underwater noise. As yet, little or no experience has been acquired with this phase and so it is not yet possible to include the effects in this framework.

5.2 Identification of sensitive species and habitats (Step 2)

The next step is the identification of species and habitats that could be affected by the pressures from the activities under consideration. In this step, a list should be made of the species (and processes) present within the sphere of influence of the pressure and the species that are sensitive to the pressures identified in Step 1. These pressures are only significant in relation to what they can disturb. In other words, they are dependent on how sensitive a certain species, habitat or process is to a given pressure, and on whether there is any overlap in space and time between the presence of a pressure and the species sensitive to that pressure.

In the KEC, we look at the species that are protected by the Environmental and Planning Act. Species listed in Annex I of the Birds Directive and Annex IV of the Habitats Directive enjoy the highest level of protection.
The KEC also looks into the ecosystem processes that potentially influence the food web and therefore the protected species. The Descriptors in the Marine Strategy Framework Directive are also taken into account, although they include no strict thresholds that can be used for the purposes of assessment.

The derivation of species-level effects from those at the ecosystem level is still in its infancy. However, as soon as more is known, that knowledge will be included in the KEC. The same applies to the presence of prey and the effects of offshore wind farms on those prey-animals.

The list of species covered in the Part B reports is reviewed periodically. Due to shifts in the presence of species (both in terms of numbers and locations of occurrence) or due to the future locations of offshore wind farms (for example, further out to sea, where there are different species than near the coast), other species may have to be taken into account in the calculations of the effects.

5.3 Inventory of other relevant activities with effects (Step 3)

This step identifies all the other relevant activities in or in the vicinity of the plan area. It is important to realise that proximity to the plan area is not necessarily as significant for the inventory of other relevant activities as the area within which the relevant effects on the species or habitats concerned could occur. For highly mobile animals, such as birds and harbour porpoises (with the exception of migratory fish or bats), the areas within which relevant effects could occur are large. Effects and populations do not stop at national borders, which means that the assessment should be made from an international perspective.

Only those activities that contribute to cumulative effects are considered in this step. The activities to be included should be identified on the basis of their ecological effects and the relevance of those effects, not on the basis of their legal status. Activities are relevant only if they may exert an influence on the habitats and species identified in Step 2, either via the same pressures identified earlier or via entirely different pressures (or even entirely different *drivers*). Effects on habitats or species populations other than those identified in Step 2 will not be considered.

5.4 Determination of the cumulative effects of all activities (Step 4)

This phase describes the effects of all the activities selected in Steps 1 and 3 that could affect the species and habitats selected in Step 2. However, it is advisable here to draw up a list of priorities first on the basis of expert judgement. The initial selection should be based on a qualitative assessment of the cause–effect relationships between pressures and species/habitats that could lead to significant adverse cumulative effects, the key criterion being the protection of the most sensitive species. Other, less sensitive, species will often benefit from the mitigation measures required for the most sensitive species. After a list of priorities (which must be made explicit) has been established in this way, a more detailed study will have to be made of those aspects that could lead to significant adverse effects, including those where significance is questionable.

This more in-depth study, where possible based on quantitative research or modelling studies, should indicate for each activity the extent of the effect that each pressure has on each habitat or species. If this is not possible, the extent of the effect should be determined qualitatively by expert judgement.

The set of effect assessments determined for each pressure by species or habitat forms the basis for the analysis to determine whether, and if so to what degree, the various effects of the pressures act to enhance or to weaken each other. For instance: a seabird that experiences a loss of habitat resulting from the presence of a wind farm will avoid the area and therefore be less affected by collisions. An example of effects that could enhance each other is when habitat loss and a barrier effect occur at the same time: not only is the habitat reduced in area, but the remaining area is less accessible.

The different reports (KEC parts B) provide extensive descriptions of the above.

5.5 Assessment of cumulative effects (Step 5)

This step involves assessing the effects. The determination of the size or scale of the effects, which took place in Step 4, is a value-free exercise. An objective assessment is made of whether effects actually occur; there is not yet any assessment of the severity of those effects. The latter assessment takes place in Step 5. Step 5 assigns a value to an effect. In other words, the changes in the status of the protected species at the population level and the reduction in the size or quality of protected habitats is measured against a threshold value (limit of acceptable change). This threshold is determined for species on the basis of population change in line with the principle that there should be no structural decline in population numbers. The threshold for habitats is based on the favourable conservation status; there must be no reduction in the size and/or quality of habitat in relation to the conservation objective for a site. If there is an objective for improving a habitat type, this objective must not be endangered as a result of individual or cumulative effects. In legal terms, if such a decline or deterioration is probable, the effect will be described as 'potentially significant'.

The ecological assessment of the effects seeks to establish the extent to which the adverse effects of the activity can have a significant influence on a conservation objective (such as the area or quality of a habitat or the population of a species). The natural size of a healthy species population is limited mainly by the amount of food and other environmental factors, such as the area of safe reproduction and roosting habitats required and the presence of natural predators. A temporary increase in the mortality rate may be compensated for by higher survival rates of the remaining animals and the ability to raise more offspring (density-dependent factors). Additional mortality in animal populations (due to a virus infection, for example) may be caused by unexpected temporary or permanent changes in environmental factors. The likelihood of a population recovering from a disturbance depends on the magnitude of the disturbance and the speed at which it occurs.

The mechanism described above gives the population a certain degree of ‘resilience’ against additional mortality resulting from individual or cumulative effects of human activities. But if the increase in mortality continues year after year after year, the natural carrying capacity will be affected. If recovery is not possible, the species will eventually become extinct or disappear from part of its range and, if a population is already under pressure from human influences such as pollution and disturbance, additional, cumulative, adverse effects will produce a significant effect sooner. The ‘resilience’ argument is valid only for direct adverse effects on the size and/or quality of a species’ habitat if such a loss is offset by positive effects, such as a richer environment in the remaining areas, natural migration or habituation.

The outcome of this step is an assessment of whether the cumulative effects on a habitat or species are within the limits of acceptability or not. If the cumulative

effects act to permanently reduce the size of a species population or pose a structural threat to the favourable conservation status of a habitat (expressed as area and/or quality), the activity in its proposed form is not permissible.

From an ecological perspective, the thresholds (limits of acceptable change) must ensure that the conservation status of the habitat is not adversely affected (in other words, size and/or quality are not impaired) and the population does not decline as a result of the cumulative effects of the initiative in combination with all other influences of human activities. The carrying capacity of the ecosystem for the populations of the protected species must be maintained at the level of the favourable conservation status.

Step 5 consists of 2 steps; 1) calculating effects and 2) assessing these effects on the basis of the thresholds. These calculations can be found in parts B of the KEC.

5.6 Reduction of cumulative effects (Step 6)

If the outcome of Step 5 indicates that the project or plan may have significant adverse effects, this should lead to a *response* in which measures are taken that will either reduce or eliminate the effects of the activities (*mitigation*) or otherwise ensure the maintenance of the conservation status of the affected species. The mitigation hierarchy should be taken into account (prevention, mitigation, compensation).
At first one tries to prevent effects from happening at all (prevention). This can be done by, for example, choosing the right location.
If there is a likelihood that a project will have significant adverse effects on a conservation objective that could endanger the favourable conservation status of a protected species or habitat (either as a result of the effect of the project or of cumulative effects produced in combination with other projects or plans), the next step is to investigate whether the consequences of the project can be limited to such an extent that the adverse effects are no longer significant and that the favourable conservation status is therefore no longer jeopardised. This step is called mitigation. If, despite mitigation measures having been taken into consideration, significant adverse effects on the conservation status can still not be ruled out, the project is, in its current state, not possible.

If mitigation is possible and quantifiable, it can be included in the KEC calculations. The mitigation of underwater noise from piling has, for example, been included in the report on marine mammals (Heinis, 2025).

6 Assumptions for the assessment of 'offshore wind-farm areas' in the KEC

This chapter describes the assumptions used for the calculation of the effects, i.e. turbine parameters, the area and which activities are included or not. The calculations themselves can be found in the Part B reports.

6.1 Assumptions about the wind farm areas and wind turbine characteristics.

The wind farm scenario for KEC 5.0 requires assumptions about certain technical matters, both nationally and internationally. Technical assumptions relate to, among other things, the size of the turbines, piling energy, and where the relevant farms are located. These technical assumptions are needed for ecological calculations. Thos assumptions are parameters required for the models in order to determine the effects. The assumptions are drawn up using input from relevant stakeholders and, where there is uncertainty, a worst-case approach is adopted.

A brief summary is given below of the assumptions used in the national and international scenarios. An extensive list of assumptions can be found in Annex 1.

National scenario

The national scenario is based on the offshore wind farms described in Chapter 1. Specifically, a overplanting scenario[4] has been included for IJmuiden Ver Gamma and subsequent farms in which a maximum of 15% extra turbines is assumed.

Year-round piling is assumed, with a piling energy in kilojoules (kJ) of 2,000 kJ for wind turbines with a capacity of up to 12 MW. For a capacity of 12 MW or more, a piling energy of 4000 kJ is assumed.

The underwater noise standards in the site decisions for the Dutch wind farms are assumed. For each wind farm, a single tip height, a single lowest tip height and a single height of the nacelle are used for all turbines. The estimated lifetime of the wind farms is forty years.

Specific estimated values are used in different time periods for capacity per square kilometre (MW/km²): a density of 10 MW/km² is assumed until 2025, increasing to 11 MW/km² until 2030 and 12 MW/km² until 2035. Because large areas have been set aside for search areas, both national and international, where no specific information is available on turbine density, the area is estimated based on the above densities. This estimate guides the calculations for habitat loss in bird species.

The calculations do not consider, for example, individual turbines alongside oil and gas platforms. If the capacity per turbine for a wind farm area is not known, an estimate is made: 12 MW per turbine is assumed until 2025, 15 MW or 20 MW between 2025 and 2030, and 20 MW after 2030, with an expected capacity of 25 MW after 2035.

In the case of TenneT energy platforms, a DC platform includes 16 piles and an AC platform 6 piles. Geophysical surveys and the presence of unexploded ordnance (UXO) are also included in the scenario analysis.

[4] In a overplanting scenario, a larger number of wind turbines are included in calculations than is determined officially. This results in a bandwidth for the number of turbines. The KEC includes the worst-case situation in the calculation.

International scenario
The international scenario follows the same technical assumptions as the national scenario. However, farms with only one or two turbines, such as pilot projects, are not included. Furthermore, floating farms are not included in the calculations for underwater noise. No cables or energy platforms are included in the international scenario. The standard for underwater noise is based on the applicable noise standards of the respective country.

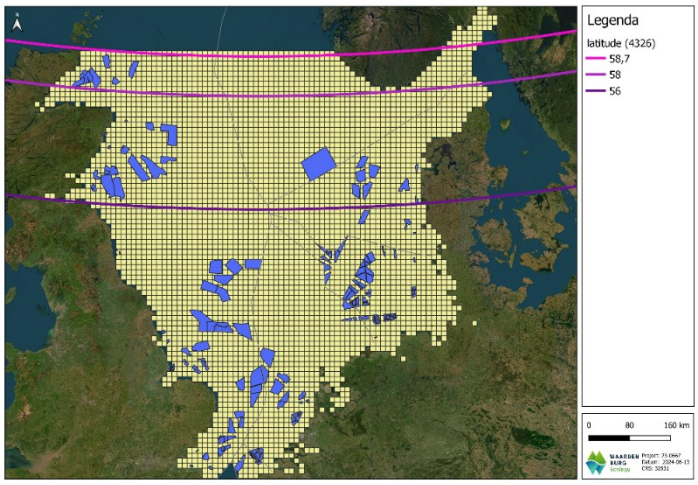
6.2 Identification of the study area

Birds
Bird experts defined a study area during the identification of effects at the level of biogeographical regions. On pragmatic grounds, it was decided to keep this study area the same for all bird species. This area is the southern North Sea (see map 2). The decision was based primarily on the characteristics of the area and the functions it has for the relevant species. This area is a relatively shallow (predominantly less than 200 m deep), warm and sheltered part of the Northeast Atlantic region.

We discovered that there was an inconsistency between the different KEC versions relating to the international study area for the KEC scenarios for birds. There were differences in northern borders of the study area in the different successive KEC versions.

The first KEC (2015) defined the study area for birds as the North Sea area between 51° and 56°. In the calculations for that first KEC, 56° was used as the northernmost limit. The underlying argument was that, at the time, there were still no wind farms to the north of 56°.
In the next KEC (2018), this study area was extended in the calculations on the basis of ongoing insights into the presence of birds, and wind farms, mainly with regard to the breeding colonies on the Scottish coast that also forage on the DCS. However, this change in the northern boundary was not correctly included in part A of the KEC 3.0 and in subsequent KECs.

In the KEC 4.0, part A included the incorrect text from the KEC 3.0. Fortunately, in the KEC 4.0 calculations, the study area was from 51°NB to 58.7°NB.



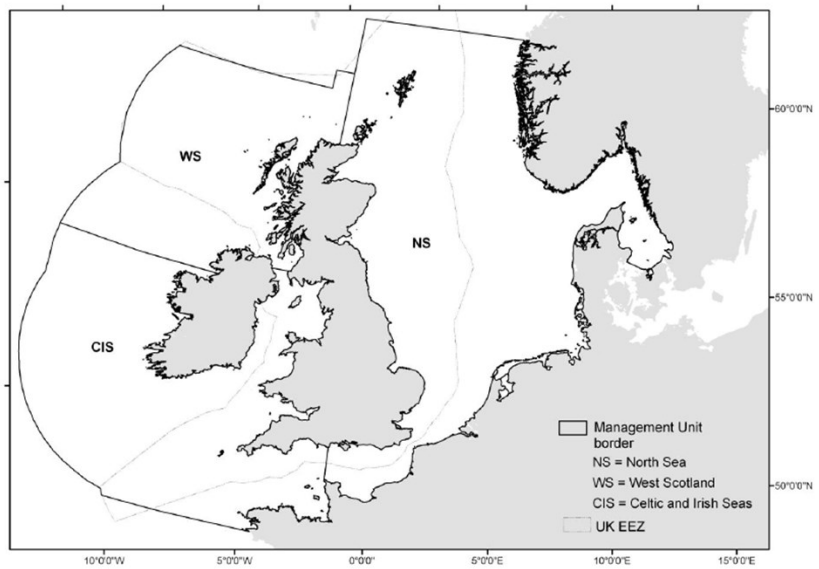
Map 2 with 56°, 58° and 58.7°

The study area must be ecologically relevant. The distribution area/habitats of particular bird species must overlap with the study area. This can differ depending on the bird species.
Most birds forage between 51°N and 58°N in the southern and central North Sea. Birds from the breeding colonies on the English and Scottish coasts, those near Helgoland and the Dutch breeding colonies all have parts of their habitat in the southern and central North Sea. These birds most likely belong to the same biogeographical population and they should be assessed in this study area.
Above 58°N, some of the birds may also forage in the northern North Sea; these species most likely belong to a different biogeographical population.
In terms of data availability, there is little difference between the lower international data availability up to 56°NB, 58°NB or 58.7°NB.

In summary, it was decided to adopt a northern border of 58°NB for birds for the purposes of the KEC 5.0.
Until now, it has not been possible to use a different (relevant) area for each species in the calculations. That is why it was decided to use a single area for all species. Even if an unduly large study area is used that is outside the range of a species (and therefore where that species is hardly present), any wind farms in that area will also have little or no effect on the overall calculations.

In subsequent KECs, the study area can be further considered to determine whether this does justice to the specific habitats of the bird species in question.

Marine mammals
The management units defined by ICES at the request of the European Commission and the OSPAR Commission (see Map 3) were adopted as a relevant sub-population for the harbour porpoise. This allocation to sub-populations is therefore internationally recognised. As the DCS population of the harbour porpoise is part of the population in the North Sea management unit, this sub-population was adopted as the basis for the calculation of international scenarios. The distribution area of seals is smaller than the distribution area for harbour porpoises. The distribution area of harbour porpoises is therefore assumed to be leading.



Map 3: Study area for harbour porpoises and seals

7 Knowledge gaps and follow-up actions

7.1 Knowledge gaps and additions to the models and methods used

There are still a considerable number of knowledge gaps relating to both methodological aspects (process, ecological, legal) and ecological aspects. Some of these gaps have been remedied with assumptions based on expert judgement; others by making pragmatic assumptions and setting up and conducting research, as in Wozep and in MONS. However, the assumptions made will have to be validated in due course where possible, preferably on the basis of the results of future research (Wozep and possibly MONS). In addition, the ecological knowledge gaps are covered in the reports in Part B.

The research community is always on the move. Research is underway into the effects of offshore wind farms on marine life, both in the Netherlands and abroad. These studies will deliver partial answers to the research questions.
Developing knowledge on time so that it can be incorporated into policy decisions when needed, for example by using it in the KEC, is and remains important.

Currently, the main bottleneck for the KEC consists of missing or as yet undeveloped knowledge that is needed for a more reliable quantitative assessment of the impact of a wind farm scenario. The main knowledge gaps are:

- the complexity of mapping the ecosystem effects of offshore wind energy developments and an ecological interpretation of those effects;
- knowledge gaps relating to the assessment of population effects in pipistrelle bats;
- species-specific population effects in migratory birds;
- the consideration of the population effects of seabirds and shore birds in context as a result of both habitat loss and collisions;
- developments in the field of turbine sizes and other foundation methods, operational underwater noise and the impact on the theme of underwater noise.

In the relevant themes of the Wozep research programme, efforts have been made to reduce these knowledge gaps. The results of these research projects have been incorporated in the KEC instruments.

The KEC instruments are improved on a continuous basis. In addition to the implementation of new knowledge regarding the elements that are already included in the KEC, the expansion of the KEC calculations to include other wind-farm-related activities, or nearshore/coastbound wind farms, is also being considered. The approach to working with, for example, the Marine Framework Directive or adding up the effects of UXO clearance on marine mammals, is also considered.

Further developments needed for the KEC are listed below. These points are closely connected to, or receive input from, the Wozep projects:

Birds

General points:

- Incorporation of the results from the update of the list of bird species to be assessed in the KEC.
- If new species emerge, new density maps and population models will be developed for those species, including a knowledge base update for the most recent model parameters.
- Development of a methodology for assessing barrier effects.
- Looking at the bird study area and ways of doing this in species-specific ways. This includes looking at the possibilities of including relevant nearshore and coastal wind farms. The development of a method for adding up habitat loss and collision victims.
- The development of an ALI status approach for the Conservation Status.
- Possible matters from an international review that is yet to be conducted.

Collisions:

- Working on improved species-specific implementation for migratory birds.
- Review of the possibilities of using an operational wind farm calendar with different start and end years for the different wind farms.

Habitat loss:

- Incorporating the version of the HALOMAR model developed further in the Wozep programme.

Maps

- Improvements in the maps for birds on a species-specific basis in various respects (time variation, underlying covariates, population dynamics and long-term density maps).
- If new species emerge from the update of the list of bird species for which there are currently no maps, the creation of those maps. Looking at possibilities for new seal maps and porpoise maps on the basis of Wozep research.
- The further elaboration and development of useful international maps for birds.

Marine mammals

- An expert elicitation about the iPCoD and PCoD energetics model.
- Incorporating the latest data from seal tagging and working towards a new methodology for seals.
- Further development of the combination of different effects such as: effects of foundations, geophysical surveys, UXOs and continuous underwater noise.
- Analyis of the data about the underwater noise actually produced.

Bats

- Further development of a suitable methodology for the KEC based on a new approach as described in the KEC 5.0.

Ecosystem effects

- Research into how the ecosystem methodology can be made more suitable for the KEC.

MSFD

- Further development of the assessment methodology for MSFD descriptors in relation to the effects of offshore wind energy.
- Addressing knowledge gaps in relation to the descriptors and criteria in the MSFD.

General issues

- International (and national) review of KEC 5.0 update.
- Inventory of potential ecological effects of dismantling offshore wind farms.
- Looking at options to include discounting in the population.
- Looking at options to include the decommissioning of wind farms in the scenarios and calculations.

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Annex 1 Assumptions for the KEC 5.0

The Wozep Steering Group drew up the technical assumptions document. TenneT, RVO.nl, the Site Decision Team, the Partial Revisions Team and Wozep Steering Group supplied input.
This text is accompanied by shapefiles and an excel table with a national and international scenario. They can be obtained from the Wozep repository.
This assumptiondocument builds on the KEC 4.0 assumptions document and the latest insights have been added.

It is intended to provide all the various researchers working on the different parts of the KEC with the same technical data. These technical data are required for ecological calculations. They are parameters needed in the models to determine the effects. The parameters include by example numbers of turbines, lowest tip levels and underwater noise thresholds.

It also includes GIS shapefiles and GIS tables. Those shapefiles and tables cover the national and international wind farms, including the technical data below (to the extent that this is possible). This includes the actual turbine types, noise thresholds, floating or not, for the windfarms that have already been built. The approved boundary conditions have been considered for the farms for which permits have been granted. Where no permits have yet been processed, the technical assumptions below have been used.

This document does not cover the substantive ecological knowledge and assumptions, only those relating to the scenarios.

Scenario

The assumptions used for the drafting of the national and international scenario are listed below:
- the scenario has been established with due care;
- it is designed to produce a good model prediction over the entire implementation period.

With respect to future site decisions:
- site decisions use bandwidths based on the state of the art at the time;
- and it is possible that the permissible bandwidth for a specific site decision for a species of interest may involve a marginally more negative or positive effect than that on which the model is based for the entire range;
- the overplanting-scenario will be considered.

National scenario

- 1st generation wind farms (OWEZ and PAWP): Although the permits for these farms are expiring, they have still been included because renewal applications are currently in place. On the basis of the worst-case approach, they will therefore be included in the scenario;
- 2nd generation wind farms (Luchterduinen and Gemini);
- the 2023 Roadmap as constructed (Borssele, Hollandse Kust Zuid, Hollandse Kust Noord);
- the 2030 Roadmap (Hollandse Kust West VI Ecowende and VII Oranjewind, IJmuiden Ver Alpha, IJmuiden Ver Beta and IJmuiden Ver Gamma)
- Roadmap 21 GW (Nederwiek (zuid) I, Nederwiek (noord) II and Nederwiek (noord) III, Hollandse Kust West VIII, Ten Noorden van de Waddeneilanden, Doordewind I);

- A overplanting-scenario has been included for IJmuiden Ver Gamma and subsequent farms as a worst-case approach (largest number of turbines) (maximum 15% overplanting);
- Assuming year-round piling based on the worst-case approach. Here, the noise standards and number of turbines as site decisions have been included as a basic assumption[5];
- Assume monopiles;
- Piling energy is 2000 kJ below a maximum capacity of the wind turbine of 12 MW; for a capacity of 12 MW or more, a piling energy of 4000 kJ is assumed;
- The noise standard for the Dutch farms is as stipulated in the site decisions. For IJmuiden Ver Gamma and Nederwiek (zuid) I, 164 dB and/or a corresponding number of harbour porpoise disturbance days are assumed. Calculations are being made for future wind farms;
- A single highest tip level, lowest tip level and axis height in each farm. In the case of the Ecowende farm with turbines with multiple tip levels, there will be discussion with the researchers to see whether differentiation is possible or whether a worst case will be assumed;
- Wind farm life 40 years;
- Number of MW/km2:
    - Until 2025 10 MW/km2
    - Until 2030 11 MW/km2
    - Until 2035 12 MW/km2
- Large areas have been set aside for search areas (national and international). This results in an unrealistically large footprint. Parts of search areas will be eliminated during further planning/site allocation. Where turbine density information is not available, the area has been estimated based on the density in the previous bullet point (i.e. 10MW, 11MW or 12MW/km2). This is a more realistic surface area. The estimated value is leading for habitat loss;
- Approximately 10% of turbines shut down in spring/summer for management and maintenance during daytime operational hours (7:30 AM - 4:30 PM). On the basis of information received from Rijkswaterstaat from wind farm owners regarding wind availability and the maintenance of wind turbines, the assumption is that wind farms are operational 90% of the time during the day in spring and summer. We then took a weighted average for the entire day, with 90% daytime operationality for 9 hours of the day and 100% for the remaining hours, resulting in an average of 96.25% operationality in the months of March to August, and 100% for the rest of the year (Leemans et al., 2023);
- Solitary turbines near oil and gas platforms have not yet been included in the KEC 5.0. If more becomes clear in this respect at a later stage about where and at how many platforms solitary turbines may be placed, an additional scenario will be established and included for this area in a subsequent KEC.
- If the number of MW per turbine is not listed, an estimate has been made: until 2025: 12MW, after 2025 to 2030: 15 MW or 20 MW, after 2030 20 MW, after 2035 25 MW.

[5]The Borssele farm was the first farm in which a noise standard was used in the site decision Monitoring has taken place to determine whether this noise standard has been met. In some cases, less underwater noise was generated than prescribed. There may therefore have been less of an impact than stated in the KEC calculations.

Capacity	12-13-14 MW	15 MW	20 MW	25 MW
Rotor diameter	**220**	**236**	**280**	**305**
Blade length	**107**	**116**	**137**	**149**
Axis height	**±135**	**143**	**165**	**177**
Highest tip level	**245**	**261**	**305**	**330**
Lowest tip level	**25**[6]	**25**	**25**	**25**
Rotor surface	**Approximately 38,000 m2**	**Approximately 44,000 m2**	**Approximately 62,000 m2**	**Approximately 73,000 m2**
Rpm	**7-8**	**7-8**	**7-8**	
Turbine distance (RD)	**4 to 5**	**4 to 5**	**4 to 5**	**4 to 5**
Distance between turbines (m)	**880-1100**	**944 - 1180**	**1120-1400**	**1220 – 1525**
Number of blades	**3**	**3**	**3**	**3**
Blade width		**6.757**	**8.114**	
Pitch (°)		**4.285**	**3.571**	

[6] Despite the manufacturer stating 260 as the highest tip level, they themselves state in the public information that lowest tip level is 25 metres.

International scenario

- Same assumptions as the national scenario
- Same area boundaries as in the KEC 4.0
- Farms with 1 pile or 2 piles (pilot projects) not included
- If the estimates from www.4coffshore.com of how certain construction was, were low, these farms were considered only if potential MW figures were stated; otherwise, these farms were not included in the international scenario.
- Floating farms not included in underwater noise calculations. Where a decision still has to be made about floating/piling: inclusion as piling, inclusion in underwater noise calculations as a worst case. This relates to only a few international farms at present.
- No cables, no energy platforms
- It should be noted that, in 2040, a number of farms will reach the end of their useful life/permit life. Thisis not taken that into consideration.
- The prevailing noise standard of the respective country has been adopted as the standard for underwater noise.

Wind farms, national

	Status 03-2024	**Total installed capacity [MW]**	**Installed capacity per wind turbine [MW]**	**Number of turbines**
PAWP	operational	120	2	60
OWEZ	operational	108	3	36
Luchterduinen	operational	129	3	43
Gemini	operational	600	4	150
Borssele I and II	operational	752	8	94
Borssele III and IV	operational	731	9.5	77
Borssele V	operational	19	9.5	2
Hollandse Kust (zuid) I and II	operational	770	11	70
Hollandse Kust (zuid) III and IV	operational	759	11	69
Hollandse Kust (noord) V	operational	759	11	69
Hollandse Kust (west) VI	Permit granted	756	15	54
Hollandse Kust (west) VII	Permit granted	840	15	60
IJmuiden Ver Alpha	Tender phase	2010	15	134
IJmuiden Ver Beta	Tender phase	2010	15	134
IJmuiden Ver Gamma *	EIA phase	2295	15	153
Nederwiek (zuid) I *	EIA phase	2295	15	153
Ten Noorden van de Waddeneilanden	Plan phase	795	15	53
Nederwiek (noord) II *	Plan phase	2295	15	153
Nederwiek (noord) III *	Plan phase	2295	15	153
Hollandse Kust West VIII *	Plan phase	760	20	38
Doordewind I	Plan phase	2300	20	115

*The procedures for some wind farms already take a overplanting-scenario into account. In that case, the alternative with the most number of turbines is used to determine the number of MW and turbines. This will generally be the version with 15 W turbines. This therefore means, for example, 2295 MW instead of 2010 MW per farm.

TenneT platforms, geophysical surveys

TenneT Platform with respect to piling:

The following parameters are used to calculate the harbour porpoise disturbance days for the platforms:

- Number of piles per DC platform: 16
- Number of piles per AC platform: 6
- Pile diameter: 2.5m
- Pile wall thickness: 60 mm
- Hammer energy: 2000 kJ
- Hammer ram weight (S-2500 or similar): 126 mT
- Hammer anvil weight: 126 mT
- Cushion Stiffness: 20 GPA
- One day of driving per pile

Geophysical surveys

Geophysical surveys use sound to map the subsurface.
Geophysical surveys are conducted over a period of time of several (1-5) years prior to the construction of a wind farm in order to map out the bed structure in different layers and to determine whether any unexploded ordnance is present. These surveys cover both the piling area (turbines and platforms) and the route along which the cables are laid

The scenario for a geophysical survey consists of 2 sub-scenarios:

1) Detailed survey of the future wind farm area
2) Surveys of the cable route

Other assumptions are:

- Islands/hydrogen production and transport not yet considered -> possible overestimation of number of cables and piling for platforms;
- Both the wind farm areas and the cable routes are surveyed using more or less the same equipment. The noise levels will therefore be the same;
- The assumption is one platform per 700 MW for all farms up to IJmuiden;
- The assumption is one platform per 2 GW from IJmuiden, except TNW, which does not have a 2 GW grid connection;
- One corridor should be used per 2 GW (i.e. a Grid at Sea project);
- In accordance with the calculation methods used in the KEC 4.0 underwater noise report;
- Generic approach, not site-specific (no consideration of factors such as water depth);
- The same assumptions are used for both the generic and detailed surveys, except that, in the case of generic surveys, it is assumed that a sparker is used whereas the assumption for the detailed survey is that a subbottom profiler will be used;
- The assumption is a worst-case effect distance for a sparker of 3 km, and an effect distance for a sub-bottom profiler of 1 km;
- 5 km2 per day is surveyed regardless of whether a sparker or a subbottom profiler is used;
- Surveying continues 24/7, possible postponements due to weather conditions have not been considered; only operational days are counted. On days with weather delays, the equipment is not used;
- Factors such as sailing outside the area because of turning distances, or other sailing manoeuvres in order to avoid sailing lanes are not taken into consideration;
- The estimation of noise sources and propagation are in line with the KEC 4.0. They have not changed.

Search area	Surface area	Number of survey days	Disturbance area per day (km2)	Density in spring (ind/km2)	Harbour porpoise disturbance days
Borssele 3	61	6	84	0.71	365
Borssele 4 – Blauwwind	61	6	84	0.71	362
Borssele 1	56	6	84	0.8	275
Borssele 2	56	6	84	0.73	344
Borssele Site V -Two Towers	1	0.1	84	0.75	4
Hollandse Kust Zuid I	52	5	84	1.12	488
Hollandse Kust Zuid II	52	5	84	1.07	469
Hollandse Kust Noord V	94	9	84	1.42	1121
Hollandse Kust Zuid III	54	5	84	1.04	471
Hollandse Kust Zuid IV	54	5	84	1.08	491
Hollandse Kust West VI and VII	140	14	84	1.09	1284
Hollandse Kust West VIII	70	7	84	1.07	631
Ten Noorden van de Waddeneilanden	70	7	84	0.8	472
IJmuiden Ver Alpha and Beta	400	40	84	0.95	3184
IJmuiden Ver Gamma	200	76	84	0.97	3799
Search area 2 (South) - Lagelander	400	40	84	1.02	3435
Search area 5 (East original) – Doordewind	600	150	84	0.77	61.346
Search area 1 (South) - Nederwiek Zuid - Site I	200	50	84	0.8	10938
Search area 2 (North) – Lagelander	400	40	84	1.07	3610
Nederwiek Noord - Sites II and III	730	140	84		27.503

Geophysical survey wind farm/search areas

Areas not constructed during the KEC planning period, but where a geophysical survey of the search area may already have been completed:
Doordewind II: 730 km2
Lagelander: 750 km2
Area 6/7 subarea 1: 600 km2

Geophysical cable surveying

The number and speed of surveys:
For a cable, the following surveys are conducted (maximum):

1) Route survey: 1000 m wide for 2 GW and 1200 m for the 700 MW projects.
    a. 2 km2 per day as the speed due to the relatively large linear distance.
2) UXO survey: 80 m wide around each cable. So this is 1 x 80 m for 2 GW and 2 x 80 m for 700 MW.
    a. Speed 0.3 km^2 per day (small linear distance).
3) Pre-lay survey: 50 m wide around each cable. So this is 1 x 50 m for 2 GW and 2 x 50 m for 700 MW.
    a. Speed 0.3 km^2 per day (small linear distance).
4) Post-lay surveys: 30 m wide around each cable. So this is 1 x 30 m for 2 GW and 2 x 30 m for 700 MW.
    a. Speed 0.3 km^2 per day (small linear distance).

The first and third surveys are 100% certain. The other two depend on the contractor and so it is important to include these surveys in the KEC as well.

Cable length

RVO names for projects	**TenneT cable projects**	**Length of offshore cable (km), not including Wadden Sea**	**Type**	**Status**
Borssele = Borssele I, II, III, IV, V	Borssele Alpha 2 circuits	61	220 kV AC	Installed
Borssele = Borssele I, II, III, IV, V	Borssele Beta 2 circuits	67.5	220 kV AC	Installed
Hollandse Kust (zuid) I, II, III, IV	HKZ Alpha 2 circuits	42.2	220 kV AC	Installed
Hollandse Kust (zuid) I, II, III, IV	HKZ Beta 2 circuits	33.8	220 kV AC	Installed
Hollandse Kust (noord) V	HKN 2 circuits	33.4	220 kV AC	Installed
Hollandse Kust (west) VI, VII	HKW Alpha 2 circuits	69	220 kV AC	Installed
Hollandse Kust (west) VI, VII	HKW Beta 2 circuits	65.1	220 kV AC	As planned
IJmuiden Ver I, II, III, IV	IJmuiden Ver Alpha (2GW)	164	525 kV DC	As planned
IJmuiden Ver I, II, III, IV	IJmuiden Ver Beta (2GW)	146.8	525 kV DC	As planned
IJmuiden Ver (noord) V, VI	IJmuiden Ver Gamma (2GW)	157	525 kV DC	As planned
Nederwiek I, II, III	Nederwiek 1 (2GW)	205.2	525 kV DC	As planned
Nederwiek I, II, III	Nederwiek 2 (2GW)	203.8	525 kV DC	As planned

RVO names for projects	**TenneT cable projects**	**Length of offshore cable (km), not including Wadden Sea**	**Type**	**Status**
Nederwiek I, II, III	Nederwiek 3 (landfall location uncertain) (2GW)	(+/-) 285	525 kV DC	As planned
TNW	Estimated by KEC 2 circuits	(+/-) 100	If electric: 220 kV AC	
HKW III	Estimated by KEC	(+/-) 75	Estimated by KEC: 1 AC platform	
DDW I	Estimated by KEC (2GW)	(+/-) 180	525 kV DC	
DDW II *	Estimated by KEC (2GW)	(+/-) 180	525 kV DC	
DDW III *	Estimated by KEC (2GW)	(+/-) 215	525 kV DC	
Lagelander *	Estimated by KEC (2GW)	(+/-)150	525 kV DC	

* These areas will not yet be constructed during the KEC 5.0 planning period but the geophysical surveys for the cables may already be completed.

Annex 2 Legal analysis for KEC areas and species protection

28 – 11 - 2024

Pursuant to Article 6(3) of the Habitats Directive, Dutch legislation also stipulates that, in cumulation with other plans and projects, an assessment of whether a plan or project may cause significant effects (risk for the fulfilment of the conservation objectives of a Natura 2000 area) before permission can be granted on the basis of an appropriate assessment, which in turn must consider the cumulative effects.

In established case law, the Administrative Law Division of the Dutch Council of State interprets this to mean that consideration should be limited to the combination with plans or projects for which nature permits have already been granted and which have not yet been fully realised (fully realised plans and projects are deemed to be part of the background situation in nature).

A mandatory cumulation test of this kind does not apply for species protection, nor is there any case law in this respect yet. But it is not inconceivable that this aspect will be viewed in a similar way.

Permits for projects with consequences for nature impacts are already difficult enough in the prevailing legal frameworks. It would therefore not seem sensible to adopt a stricter approach in the cumulation test and to include more wind farms than necessary pursuant to case law relating to area protection.

Under case law, the cumulation test should consider only plans and projects for which nature permits have already been granted and which have not yet been implemented in full. This is the cumulation test in the context of area protection (whether a project endangers the fulfilment of the conservation objectives resulting from a Natura 2000 designation decision). It is uncertain whether a similar approach will be taken in the case of species protection. But that possibility cannot be excluded.

Some questions will be addressed below.

What is the area in which other projects must be included in the assessment?
It is forbidden to engage in a flora and fauna activity without an environmental permit. This includes the (conditional) intentional killing of birds naturally occurring in the wild in the Netherlands of species referred to in Art. 1 of the Birds Directive and intentionally disturbing those birds. The prohibition on intentionally disturbing the birds concerned does not apply if the disturbance does not substantially affect the conservation status of the bird species. See Article 11.37 Bal. That permit can be granted only if, in accordance with Art. 8.74j Bkl, there is no other satisfactory solution than the activity and the activity is necessary in the interests of, for example, public health or public safety (this would appear to be the interest that is the most appropriate in the case of wind farms), and the activity does not result in any deterioration in the conservation status of that species. A site decision in the sense of the Offshore Wind Energy Act can replace the environmental permit if the same conditions are met (Art. 7 Wwz).

Cumulation in the context of area protection
It follows from Art. 6(3) of the Habitats Directive that an assessment must be made of whether a plan or project, either on its own or *in combination* with other plans or projects, is likely to have significant consequences that jeopardise the fulfilment of the conservation objectives. In that case, the project or plan can be approved only after a positive appropriate assessment (which must, in turn, consider cumulation). In the case of a positive appropriate assessment, an environmental permit can be granted for the Natura 2000 activity or the plan can be adopted.

Which activities should be included in the cumulative assessment?
Assessments of wind farms and any other activities with consequences for nature in combination with the wind farm to be approved should be limited to forms of activities that:
1. have already been approved but not yet fully realised (by analogy with the case law for area protection), and
2. for which there is actual ecological evidence that those wind farms or other activities are located at such a distance from the wind farm to be assessed that there can actually be effects on the conservation status of the species in question. The assessment obviously becomes more difficult as more farms are allowed in a larger area at the same time and an assessment of their cumulative effects is therefore required.

In principle, it does not matter to which area or member state that distance extends. In the context of area protection, however, it is established case law that projects on Dutch territory that affect Natura 2000 areas in other Member States must be assessed in terms of their effects in that other Member State on the basis of the principle of Union loyalty and in accordance with the assessment system that applies in the other Member State in question. After all, that Member State must also comply with Article 6(3) of the Habitats Directive. Something similar could apply to species protection.

Annex 3 Differences between KEC 1.1 (2015) & 2.0 (2016), KEC 3.0 (2019), KEC 4.0 (2022) and KEC 5.0 (2025)

Birds, general:

- Population estimates come from the same density maps as the input for the calculations rather than from a range of less easily comparable literature sources. The calculated numbers should not be used separately;
- KEC 4.0 Birds new data ESAS data, added to the data (till 2020)
- Collision casualty estimates calculated using the stochastic Collision Risk Model instead of the Band model;
- KEC 4.0 Acceptable level of Impact as defined by LNV used;
- Casualty estimates stated as annual mortality probabilities based on population estimates from density maps;
- KEC 4.0 Input parameters (demographic rates) for population models updated based on new literature;
- KEC 4.0 Apportionment of victims to age classes if possible based on offshore age distribution in line with an analysis of ESAS data in WOZEP;
- KEC 4.0 Population models used for population assessment of OWF-induced mortality and test of exceedance of ALI threshold;
- KEC 4.0 Calculations made for more species than in KEC 3.0. New populations model generated for little gull, red knot, bar-tailed godwit, common tern, common starling;
- Existing population models were adjusted to include collision mortality as well for sandwich tern and northern gannet.

Bird habitat loss:

- No new knowledge that can be used for a new KEC;
- IBM (as developed in WOZEP) used for estimating mortality due to habitat loss for the northern gannet;
- KEC 4.0 Two new population models generated (northern fulmar and Atlantic puffin);
- Shipping not included;
- Barrier effects not included.

Bird collision probabilities

- KEC 4.0 sCRM used for defining collisions;
- New knowledge on the flight speed for black-legged kittiwake and shelduck, and recalculation for the stochastic Collision Risk Model for Bewick's swan, brent goose, curlew and red knot;
- Standard deviations of flight speed included in collision rate calculations for all species;
- Flight height distributions were sampled from GPS data or from modelled height distributions for 1.000 iterations;
- New insights about offshore distribution of Black Tern (cf. Potiek et al. (2019), Wozep study);
- New data on fraction of time flying for great black-backed gull, northern gannet and black-legged kittiwake;
- Updated fluxes for Bewick's swan, brent goose and black tern (cf. BirdLife International 2015, 2019);
- New information on avoidance rates from peer-reviewed literature (Cook et al. 2018);

- 90% of operationality of wind farms during daytime hours in spring and summer.

Harbour porpoises, harbour seals and grey seals, underwater noise:

- KEC 4.0: the staged procedure was also used to calculate the effects of impulsive sound on the harbour seal and grey seal populations.
- Stage 1: As in KEC 3.0, the Aquarius 4 model which was developed in the context of WOZEP was used for the calculation of noise propagation in the KEC 4.0. The use of the Aquarius 4 model results in calculation results that are a good match for the broadband noise levels measured in the field (de Jong et al., 2018);
- Stage 2: To calculate the size of the disturbed area, a dose-effect relationship for the occurrence of a significant behavioural change in harbour porpoises and seals was used in KEC 4.0 instead of discrete threshold values of SELss = 140 or 143 dB re 1 mPa^2s that were used for harbour porpoises in the KEC 4.0;
- Stage 3: The most recent data on local densities of harbour porpoise and seals were adopted (Gilles et al., 2020; Aarts et al., 2021);
- Stage 4: No changes;
- Stage 5: As in KEC 3.0 for harbour porpoises, the possible impact on both the population of harbour porpoises and the populations of harbour seals and grey seals was estimated using the Interim PCoD model (version 5.2), which was fully updated in 2018;
- Stage 6: In principle, the KEC 4.0 is based on the same ecological standard as the KEC 3.0 (2019). This means that the population decline estimated with a high degree of certainty as a result of the construction of wind farms on the DCS in the period leading up to 2030 may not exceed 5% (and that it must preferably be less).

Bats:

- No new PBR calculations were made for bats because there is no new information about population sizes or collision probabilities;
- Data about numbers present were analysed further in relation to weather data and time;
- This resulted in a proposal for the optimisation of a mitigation measure with regard to date, time of night, wind direction, temperature and wind speed.
- KEC 4.0: no new insights or calculations

KEC 5.0:

- Knowledge base updates for the themes Maps, Collisions, Habitat Loss and Underwater Noise, both methodologically and in terms of parameter values. See reports part B;
- First steps of effect assessment of alternative piling methods, UXO clearance and continuous underwater noise;
- Update calculation of ecosystem effects;
- Link between KRM and KEC;
- Update phased procedure for impact on bats;
- Further development of the 'Acceptable Level of Impact' (ALI) methodology;

Reports:

KEC 1.1 and 2.0:

- Cumulative effects of impulsive underwater sound on marine mammals; TNO 2014;
- A first approach to deal with cumulative effects on birds and bats of offshore wind farms and other human activities in the Southern North Sea; Imares 2015.
- Framework for Assessing Ecological and Cumulative effects for the roll-out of Offshore Wind Energy, Part A - Methods - 2016 update Chapters 1.5 and 5.6;
- Framework for Assessing Ecological and Cumulative Effects and the roll-out of Offshore Wind Energy, Part B - Description and assessment of the cumulative effects assuming the implementation of the Offshore Wind Energy Roadmap - Version 2.0 26 May 2016.

KEC 3.0

- Framework for Assessing Ecological and Cumulative Effects – 2018. Cumulative effects of offshore wind farm construction on harbour porpoises. F. Heinis, HWE, C.A.F. de Jong, S. von Benda-Beckmann & B. Binnerts, TNO, 2018;
- Cumulative effects of offshore wind farms: loss of habitat for seabirds. Update for five seabird species until 2030. J.T. van der Wal, M.E.B. van Puijenbroek, M.F. Leopold, WMR 2018;
- Mitigation measures for bats in offshore wind farms. Evaluation and improvement of curtailment strategies. M. Boonman, Bureau Waardenburg, 2018;
- Update of KEC bird collision calculations in line with the 2030 Roadmap. Dr. A. Gyimesi, *ir.* J.W. de Jong, Dr. A. Potiek, E.L. Bravo Rebolledo MSc, Bureau Waardenburg 2018;
- Memorandum: Adding OWEZ and PAWP to the KEC 3.0 calculations. A. Gyimesi & J.L. Leemans, Bureau Waardenburg, 2018;
- Workshop Memorandum, 12 July 2018. E.L. Bravo Rebolledo & A. Gyimesi, Bureau Waardenburg, 2018.

KEC 4.0

- Cumulative impact assessment of collisions with existing and planned offshore wind turbines in the southern North Sea. Analysis of additional mortality using collision rate modelling and impact assessment based on population modelling for the KEC 4.0. Potiek A., Leemans J.J, Middelveld R.P, Gyimesi A. March 2022
- Acceptable Levels of Impact from offshore wind farms on the Dutch Continental Shelf for 21 bird species. A novel approach for defining acceptable levels of additional mortality from turbine collisions and avoidance-induced habitat loss. Potiek A., IJntema G.T., van Kooten T., Leopold M.F., Collier M.P., March 2022
- Advice on future assessment of ecosystem effects from offshore wind farms. Advice for KEC. van Duren L., November 2021
- Cumulative population-level effects of habitat loss on seabirds 'Kader Ecologie en Cumulatie 4.0', F.H. Soudijn, F.H., Hin v., van der Wal J.T., van Donk S., March 2022
- Framework for Assessing Ecological and Cumulative Effects 2021 (KEC 4.0) – marine mammals. Heinis F. (HWE), de Jong C.A.F., von Benda-Beckmann A.M., January 2022
- Northern gannet collision risk with wind turbines at the southern North Sea. Extension of the impact assessment for KEC 4.0, additional analyses of the assessment framework. Collier M.P, Potiek A., Hin V., Leemans J.J, Soudijn F.H., Middelveld R.P, Gyimesi. A, March 2022

- Density maps of the herring gull for the Dutch continental shelf. Memo to supplement the seabird assessment reports within KEC ("Kader Ecologie en Cumulatie") 4.0. Soudijn F.H., Chen C., Potiek A. van Donk, S. March 2022. Evaluation and improvement of curtailment strategy, M. Boonman, Bureau Waardenburg, 2018

KEC 5.0

- Impact of offshore wind farms on the North Sea ecosystem. Scenario study for the partial revision of the Dutch offshore wind planning. Zijl et al, 2024.
- Collision effects of North Sea wind turbines on bird species within the "Kader Ecologie & Cumulatie (KEC) 5.0. Actualisation of models, data and predicted mortality for Dutch offshore wind development scenarios. G.J. IJntema, N. Heida, J.J. Leemans, A. Gyimesi, A. Potiek, 2025
- Population level effects of displacement of marine birds due to offshore wind energy developments, KEC 5. F.H. Soudijn, M. Poot, V. Hin, C. Chen, E. Melis, D. Benden, 2025
- KEC 5.0. Report Part B Marine Mammals, Heinis et al, 2025
- New approach to quantitatively estimate bat casualties at offshore wind farms, B. Jonge Poerink (Ecosensys), R. Brabant (KBIN), 2025
- Marine Strategy Framework Directive descriptors in relation to OWFs and Framework for Assessing Ecological and Cumulative Effects (KEC 5.0). M. Verdonk (RWS), M. Graafland (RWS), Q. Schürmann (WE), D. Barbé (WE), 2025.

Underlying reports and memoranda:

- Letterreport Seals. Reference 2426147.SBr.mw., S. Brasseur, G. Aarts, 2024.
- Letterreport Resident cetacean species in the North Sea. Reference 431100012-24/21. Geelhoed, 2024
- Letterreport Changes in Harbour porpoise distribution in the North Sea. Reference 2424737.SG.mb. S. Geelhoed, 2024
- Knowledge-update KEC5 density maps seabirds. S. van Donk, 2024.

Annex 4 Thresholds

Threshold for harbour porpoises, harbour seals and grey seals
In order to set acceptable limits for the effects on the harbour porpoise *Phocoena phocoena*, the harbour seal *Phoca vitulina* and the grey seal *Halichoerus grypus*, it is important to bear in mind the conservation status of harbour porpoise and seals on the Dutch Continental Shelf (DCS). The Ministry of Agriculture, Fisheries, Food Safety and Nature (LVVN) has decided that the harbour porpoise population and the populations of both seals should not fall below 95% of the current population as a result of wind farms. A further requirement is that there must be a high level of certainty (95%) that the population will not decline further as a result of wind farms. Under the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS), the interim target that has been set for harbour porpoise is that the population should not fall below 80% of the carrying capacity. It is not known what this capacity is on the DCS. Maintaining the populations of harbour porpoise, harbour seal and grey seal with a high degree of certainty at a minimum of 95% of its current size in the context of the construction of offshore wind farms for the entire period until 2032 can be considered to be a safe choice.

Threshold for birds
Two methods are used at present to determine the threshold for significant effects on birds in the EIAs. These are used in a two-step approach in the assessments: if the ORNIS criterion is not met, the ALI must be assessed.

ORNIS criterion
This criterion, which was drawn up by the ORNIS Committee, states that each increase in mortality of less than one per cent of the annual natural (adult) mortality rate[7] of the population concerned (average value) can be considered to be not significant in the absence of any contrary scientific evidence. The Court of Justice uses this criterion as its benchmark for assessing whether an effect is significant or not (e.g. case C-79/03 (Commission/Spain)). In this regard it is important to realise that a better assessment method should be used as soon as it becomes available, also from a legal point of view. In practice, when adequate data are available on the mortality rate of a population, this criterion can be used to determine whether it is possible to rule out any significant effects. If the extra mortality rate of a species due to the effects remains below the threshold, it no longer has to be considered in the assessment. If the extra mortality exceeds the 1% threshold, the effect may be significant and a more detailed investigation of possible population effects will be necessary.

ALI
The acceptability of the effects is determined in the KEC (2015, 2016, 2019) for birds and bats on the basis of Potential Biological Removal (PBR). PBR uses population size and a recovery factor to determine the order of magnitude of a possible decline or reduction in the population that is acceptable from the perspective of the population dynamics. The smaller the recovery factor used in this PBR, the more sensitive a population is and the lower the number of individual victims. The use of PBR as an acceptable measure has been criticised (for example by O'Brien et al., 2017 and Buij et al., 2018) for not being sufficiently cautious.

[7] It should be noted that it will be possible to determine the annual mortality of a species only if enough population-dynamic parameters for that species have been measured in the field.

A new methodology for identifying Acceptable Levels of Impact (ALI) has therefore been defined. Since the development of the ALI methodology in 2021, there have been several reviews and a sensitivity analysis that have been used as a basis for the further development of the ALI.

The ALI methodology (last version: Hin et al., 2024) is a method that uses population models to quantify the relative effect of offshore wind farms by comparison with a scenario without offshore wind farms. The ALI methodology compares the outcome of a scenario with an impact with a counterfactual scenario without this impact. The X threshold of the ALI describes the maximum allowable decrease (in percentages) compared to a scenario without impact. The Y threshold refers to the probability that a deterioration of more than X% will still occur in the scenario with an impact.
The strictness or flexibility of the assessment of the effects on a particular bird species do not depend on the methodology but on the thresholds. The Ministry of LVVN is responsible for the thresholds associated with the ALI methodology. Regardless of the methodology, these thresholds can be adjusted in the light of new insights. Nevertheless, if the methodology is changed, as with the first ALI methodology and the one from 2024, the ALI threshold also has to change. When setting thresholds for the ALI methodology, the Ministry based its decision on the Dutch Conservation Status (SvI), with additional information including the national trend and the international IUCN classification.

Favorable Reference Value
Ideally, in addition to the current ALI methodology, testing should also be carried out using a fixed reference value such as the Favorable Reference Value from the Conservation Status, which describes a minimum required population size for many species (the 'legal' assessment). This should include not only the effects of offshore wind energy but also all other activities at sea and on land that affect the species in question, and all more or less natural factors that have an effect, such as climate change and bird flu. There is currently no practical approach available for these calculations, although this is one of the plans for future development. It will require the further development of a methodology in addition to the ALI. At present, unfavourable population status due to the impact of offshore windfarms can be prevented as much as possible by choosing an X% that reflects the current conservation status of the population, and taking into account the current trend in population development. Because the ALI threshold is based on the Dutch SvI, the assessment is mainly intended for the Dutch situation.