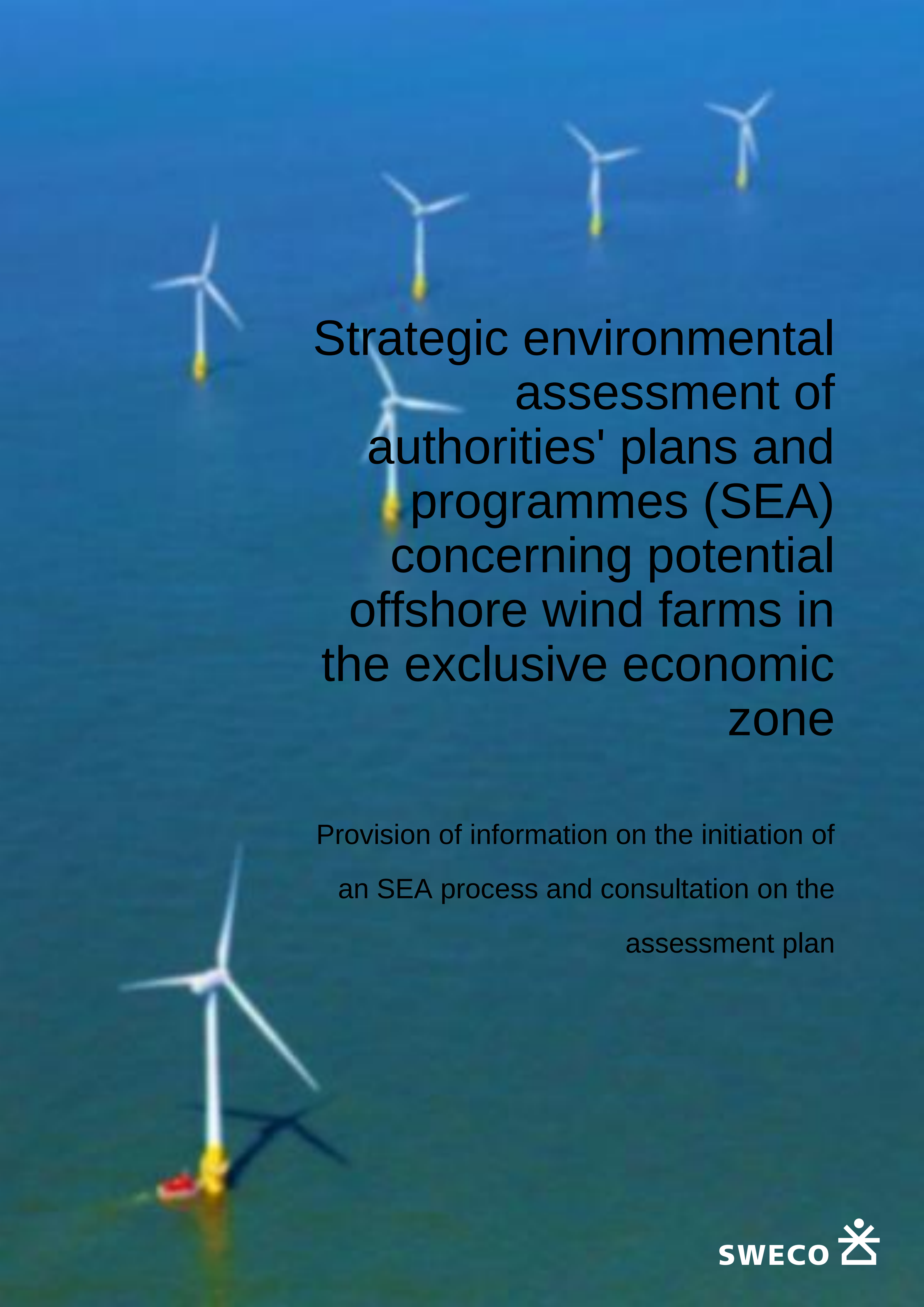


Strategic environmental assessment of authorities' plans and programmes (SEA) concerning potential offshore wind farms in the exclusive economic zone

Provision of information on the initiation of an SEA process and consultation on the assessment plan

SWECO

Contents

1 Introduction to the consultation process

The environmental impacts of certain types of plans and programmes of the authorities must be assessed pursuant to the Act on the Assessment of the Effects of Certain Plans and Programmes on the Environment (200/2005, the so-called SEA Act). This obligation also applies to the Government's decision on offshore wind farm sites in the exclusive economic zone, even if it is a decision rather than a plan in the strict sense.

Before the decision is made, the environmental impacts of the draft decision must be assessed in an SEA process. The Ministry of Economic Affairs and Employment, which is preparing the decision, has commissioned an assessment of the draft decision. The SEA assessment will be conducted in 2025 by Sweco Finland Oy, whose expert team's competence covers both offshore wind power and sustainable use of seas in a broader sense, marine ecology, maritime sectors and the SEA process. The Ministry of the Environment also has its representatives in the steering group of the assessment.

Object of the assessment in brief

Pursuant to the Act on Offshore Wind Power in the Exclusive Economic Zone (937/2024), the Government may make a decision that concerns reserving a site located in Finland's exclusive economic zone for wind energy generation (*offshore wind farm site in the exclusive economic zone*), competitive tendering regarding the site, and the conditions for using the site. Finland's exclusive economic zone is an international sea area that Finland can exploit for such purposes as offshore wind power production. The Government will make its decision on the Ministry of Economic Affairs and Employment's presentation. The decision will designate one or more sites in Finland's exclusive economic zone for offshore wind power production as well as specify the timeline for the competitive tendering process concerning concessions to use the site(s) in question. The tendering process will be organised by the Finnish Energy Authority. The decision may additionally impose conditions on the use of the site.

In the SEA process, the assessment is limited to the offshore wind farm sites in the exclusive economic zone and the transmission connections to land required for energy generation set out in the draft decision as well as the geographical area affected by their impacts. While the potential use of the produced energy on land and its transmission in the mainland grid are not covered by the actual impact assessment, their essential aspects can be described as background for it.

The Ministry of Economic Affairs and Employment submitted key information on the draft decision to the party carrying out the SEA assessment on 31 March 2025.

Information provision and consultation as part of the SEA procedure

This assessment process will include two national and international consultation rounds as provided in the Convention on Environmental Impact Assessment in a Transboundary Context ('Espoo Convention´). The first phase includes a *consultation on the planning of the environmental assessment and preparation of the environmental report*. In the second phase, which is expected to take place in autumn 2025, a consultation on the actual environmental report will be organised.

The documents of the present first consultation round describe the conduct of the assessment and the main features of the issues to be addressed in it. The statements received in consultations required under the Act on the Assessment of the Effects of Certain Plans and Programmes on the Environment will be archived and published in due course as an appendix to the final environmental report and in summary form (Appendix 1 to the actual environmental report). The summary will also comment on changes made on the basis of the statements.

1.1 Background and purpose of the SEA procedure

The objective of the SEA is to carry out an environmental impact assessment compliant with the SEA Act to support the Government in making its decision on the offshore wind farm sites in the exclusive economic zone. This is a strategic environmental impact assessment of plans and programmes ('SEA assessment') carried out to support the preparation of the public administration's plans and programmes.

The assessment includes:

1. Identification and assessment of the likely significant environmental impacts of offshore wind farm sites in the exclusive economic zone
2. The monitoring plan referred to in section 12 of the SEA Act
3. The environmental report referred to in the SEA Act and Decree
4. National information provision and consultation referred to in the SEA Act in different phases of the work
5. Processing of the statements and views received during the commenting round and in other consultations as part of the environmental report.

The SEA assessment will support sustainable implementation of offshore wind power generation by producing background material for private and public actors in the sector. The assessment will identify framework conditions relating to the environment and society within the limits of which offshore wind power projects can be implemented and which can mitigate their harmful impacts and risks. The commenting round and consultation will strengthen the social acceptance of offshore wind farms in the exclusive economic zone while providing basic information and starting points for project-specific planning for actors in this sector. The SEA process will support project actors’ ability to manage their risks by defining the framework conditions for the activities, which will also increase the attractiveness of wind farms as investments.

The purpose of the SEA assessment procedure and the resulting report is not to comment on the approval of offshore wind power projects or on the feasibility of individual wind turbine projects from a technical, economic or legal perspective. Its aim is to assess the draft decision itself and to produce information on the impacts of its implementation on the environment. A well-implemented SEA assessment can boost the benefits or acceptability of plan implementation or bring up the best ways of identifying and minimising negative impacts.

While the SEA procedure does not replace the statutory environmental impact assessment procedure (EIA) and permit processes of an individual power plant project, actors conducting EIA processes can draw on the documents and statements of the public SEA procedure to improve the quality and acceptability of their processes.

1.2 Course and objectives of the SEA procedure

An SEA is an ex-ante assessment carried out before the framework conditions for concrete projects have been defined; this is why it involves many uncertainties. Its essential task is to pinpoint the most significant impacts by putting them in perspective (and by modelling if necessary), to highlight differences between implementation alternatives, and to identify ways to mitigate significant impacts.

At the core of the process is gathering relevant existing data, analysing them from the perspectives of the frame of reference and different stages of the offshore wind farm project, and refining the results to serve the public administration, companies and stakeholders alike. The available data determines how detailed the results will be. Rather than carrying out field studies or producing significant new data, the SEA is based on existing data and information gaps.

As provided in the SEA Act, the assessment includes describing the current state and characteristics of the environment in the area under review and assessing the impacts of the draft decision on, among other things, biodiversity, biota, vegetation, water, soil, air and climate factors, population, human health, living conditions and comfort, landscape, urban structure and built environment, tangible property, cultural heritage, exploitation of natural resources and the relationships between these factors.

It additionally examines the draft decision's relationship to other plans and programmes.

The assessment process is carried out ensuring that it meets the requirements of the Act and Decree (Government Decree 347/2005) on the Assessment of the Effects of Certain Plans and Programmes on the Environment and relying on the Guide on environmental assessment under the SEA Act (Paldanius 2017) as well as the Guide on ecological surveys and ecological impact assessment (Mäkelä & Salo 2023). The course of the SEA assessment (see Figure 1) is specified in regulation and guidelines.

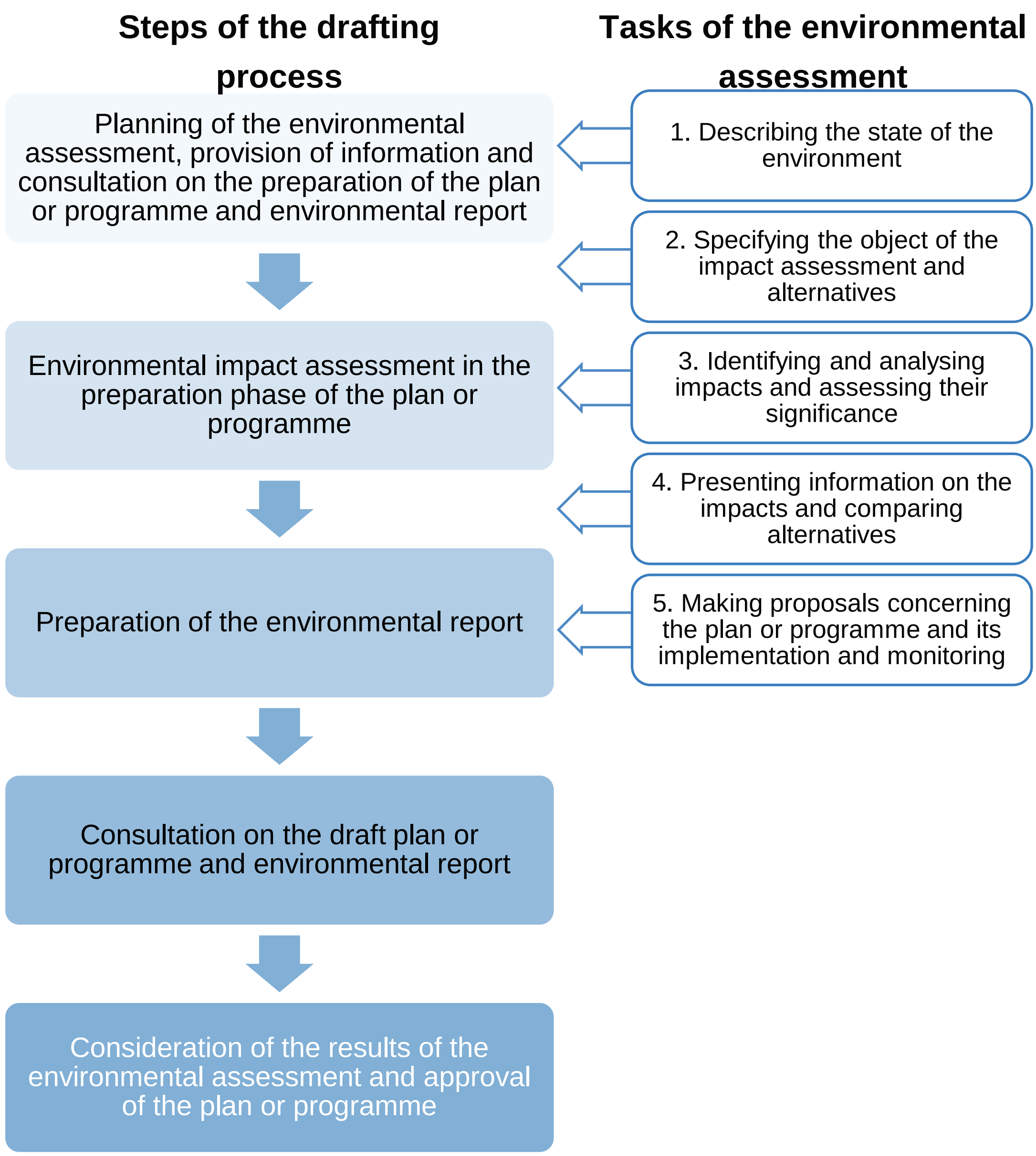


Figure 1: Course of the SEA process and the content of the different steps. Adapted from the Guide on environmental assessment under the SEA Act (Paldanius 2017).

2 Object of the assessment

2.1 Content of the draft Government decision on offshore wind farm sites in the exclusive economic zone

The assessment concerns the draft Government decision on offshore wind farm sites in the exclusive economic zone, even if it is a decision rather than a plan in the strict sense. Pursuant to the Act on Offshore Wind Power in the Exclusive Economic Zone (937/2024), the Government may make a decision that concerns reserving a site located in Finland's exclusive economic zone for wind energy generation (*offshore wind farm site in the exclusive economic zone*), competitive tendering regarding the site, and the conditions for using the site. Finland's exclusive economic zone is an international sea area that Finland can exploit for such purposes as offshore wind power production. The Government will make its decision on the Ministry of Economic Affairs and Employment's presentation. The decision will designate one or more sites in Finland's exclusive economic zone for offshore wind power production as well as specify the timeline for the competitive tendering process concerning concessions to use the site(s) in question. The tendering process will be organised by the Finnish Energy Authority. The decision may additionally impose conditions on the use of the site.

At this stage, the draft decision firstly comprises the four proposed offshore wind farm sites (see Figure 2), without yet commenting on the number that will actually be put out to tender or the schedule of the tendering processes. Secondly, the draft decision sets the following conditions:

- The efficiency of site use is 5MW/km2. This means that the wind power project may ultimately take up a smaller area than the one tendered for if this efficiency requirement is met.
- The site may be used to exploit wind energy. This also includes a concession to use the site for secondary energy production (such as a hydrogen plant) if the necessary permits are obtained.
- The term of the concession is approx. 30 years.
- If the wind farm to be built on the site is connected to the Finnish main grid, the maximum capacity that can be connected to the main grid connection point will be 1.3 gigawatts.

The Government decision concerns the selection of areas as potential sites for offshore wind farms. Project development by the wind power company, in which the environmental impacts of the project will be assessed in much more detail in the EIA process and the permits required for the construction of the wind farm will be applied for, will only start once the tendering process for each site has been completed.

Two of the four sites are located in the Bothnian Sea (West and East) and the other two in the Bothnian Bay (South and North). The sites Bothnian Bay South and North and Bothnian Sea East are delimited by the boundary of the Finnish territorial waters; the site Bothnian Sea West is located close to the boundary between the exclusive economic zones of Sweden and Finland.

The total surface area of these sites is 921 km^2. The surface areas of the sites are:

- **Bothnian Sea West: 211 km^2**
- **Bothnian Sea East: 202 km^2**
- **Bothnian Bay South: 284 km^2**
- **Bothnian Bay North: 224 km^2**

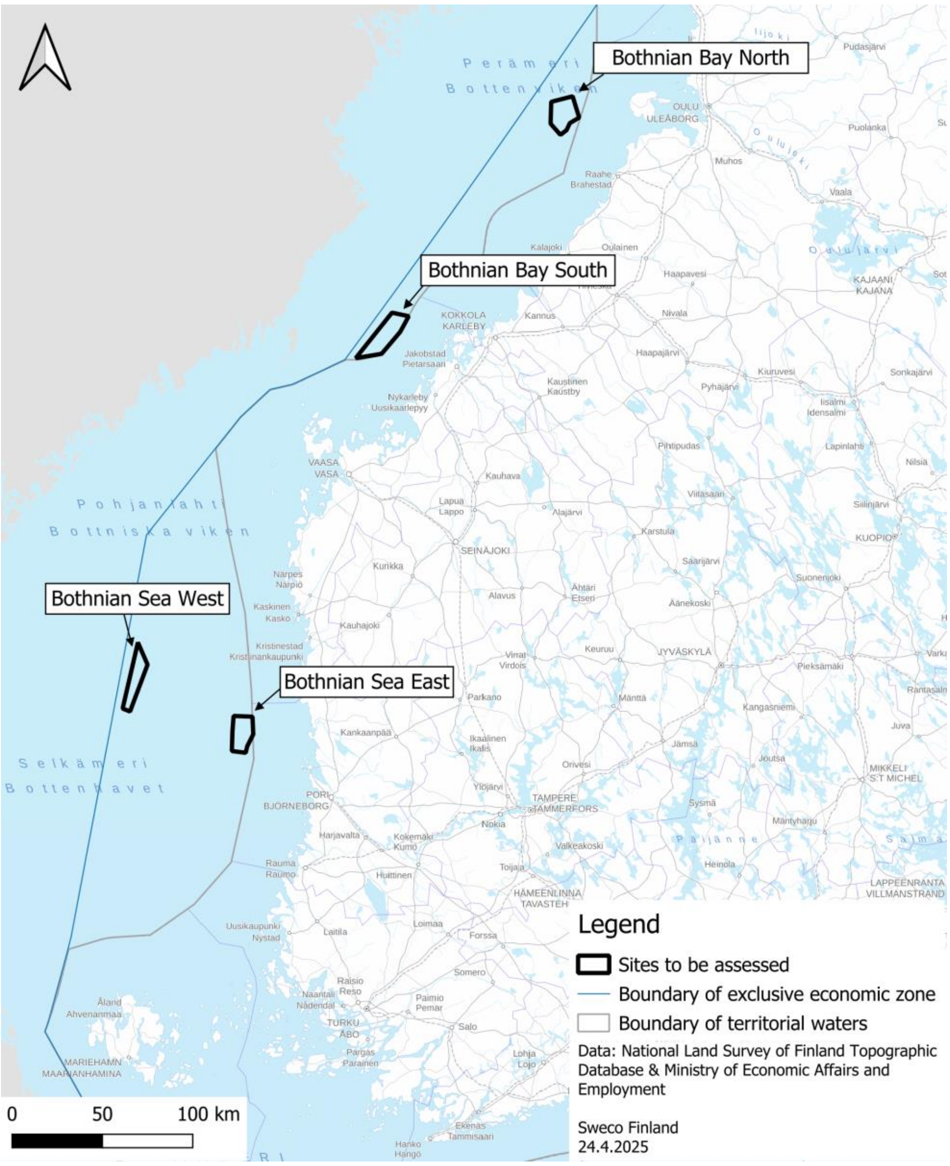


Figure 2: Locations of the sites designated in the draft decision to be assessed.

The responsibility for drafting the decision on offshore wind farm sites rests with the Ministry of Economic Affairs and Employment, which submitted information on the draft decision essential in terms of the SEA assessment to the actor carrying out the assessment on 31 March 2025.

2.2 Life cycle and general technical implementation methods of an offshore wind power project

Offshore wind power refers to wind power production in sea areas; wind power production in land areas is correspondingly called onshore wind power. The essential feature of offshore wind power is that the sites on which electricity is produced are located far away from the majority of land-based end users. This is particularly true for production sites in the exclusive economic zone far from the coast.

In the context of the SEA assessment, offshore wind power refers to the complex consisting of turbine units and the infrastructure they need on the production site as well as transmission of electricity to the onshore grid. The production site infrastructure includes internal cables and an offshore substation. Power transmission to land comprises a connection cable leading from the offshore substation to an onshore connection point. However, the Government decision on site selection will not apply to cables, and transmission of electricity to land is not mandatory.

The SEA assessment is based on the available information and current, widely used solutions in the sector. The SEA assessment does not cover the manufacture of offshore wind farm components and the origin of raw materials. The assessment, comparison and selection of different technical solutions for offshore wind farms are part of the project-specific planning and environmental impact assessment (EIA) procedure as well as the project's permit processes.

2.2.1 Project life cycle

The life cycle of an offshore wind farm project covered by the SEA assessment consists of four phases (see Figure 3). The emissions and waste generated during the presented life cycle are covered by this assessment. As a stage, the SEA itself is not included in the presented life cycle and comes before the preliminary studies and planning of the project.

The **preliminary study and planning phase** covers surveys and scientific studies on the site, planning of the farm and electricity grid, and selection of technical solutions. This phase includes the EIA and permit procedures.

After the studies and planning and once the EIA and permit procedures have been completed, an offshore wind farm and its infrastructure can be built. **Construction** includes seabed intervention, installations at sea, cable laying, soil disposal, sea and land transport; and also port operations, including intermediate storage and pre-assembly. The construction activities will depend on the selected technology and the number of sites to be built.

Once the construction work has been completed, the **production and maintenance** phase of the project will begin. This is the phase with the longest duration. It includes monitoring, servicing and maintaining the turbines and submarine cables as well as the transport of crews and spare parts needed for these activities. This phase also involves possible environmental monitoring obligations and follow-up studies.

The current service life of an offshore wind turbine is approximately 30 years, after which it will be decommissioned. The **decommissioning phase** includes transport and demolition work on the farm site and activities associated with them in ports. This phase also comprises any environmental restoration work, recycling of materials and waste management. This SEA assessment assumes that the structures will be dismantled above and below water level at the end of the project, at least to the depth required for maritime safety. In addition, the phase includes any post-demolition environmental monitoring studies.

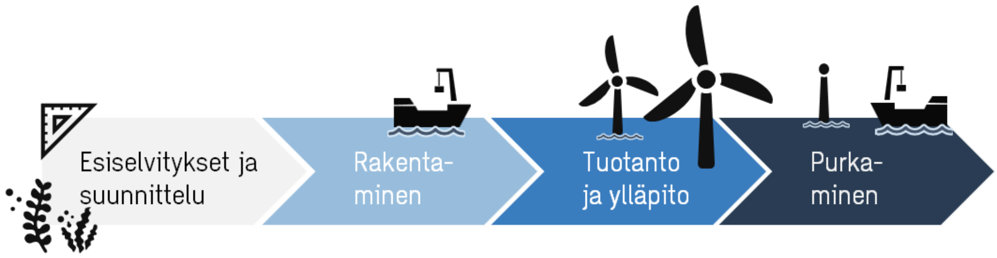


Figure 3: The phases and life cycle of an offshore wind power project from planning to decommissioning.

2.2.2 Common technical implementation methods

Structure and size of the wind turbine

The technical implementation includes deciding on the size of the wind turbine. In this context, the size refers to the total height of the turbine unit, including the tower and the rotor with its blades. In other words, the total height is measured to the tip of the rotor blade when it is pointing upwards. The axis of the wind turbine can be either horizontal or vertical; in most cases, the axis is horizontal.

The size of the wind turbine affects its power generation capacity: larger turbines produce more electricity than smaller ones. Fewer larger turbines are needed to achieve the same production capacity. The size of the wind turbine also affects its environmental impacts. For example, as larger wind turbines are higher, the landscape impact and bird collision risks they create are greater, whereas more seabed foundations need to be built if a larger number of smaller turbines is decided on. The size of the wind turbines also affects their proximity to each other: larger wind turbines require more space around them than smaller ones.

In the implementation alternatives of the EIA programmes for projects planned in Finland, the power plants vary from 15 MW to 30 MW in capacity, and from 260 to 400 metres in total height. In the plan under review, the maximum and minimum total output have been defined, rather than the capacity or other technical characteristics of an individual wind turbine.

Foundations and placement

There are various technical solutions for building wind turbines, and the essential differences in the case of offshore wind turbines concern the implementation of their foundations. The selection of foundation technology is influenced by the characteristics of the production site to be set up, including seabed quality and water depth. The placement of wind turbine units can be decided taking local environmental and natural conditions into account. Deciding on their placement and foundation type will be part of the mitigation measures associated with individual wind turbines.

The environmental impact assessment programmes for offshore wind power projects published in Finland (EIA programmes for offshore wind power projects in the economic zone) and the Swedish Environmental Protection Agency's compilation report (Bergström et al. 2021) discuss foundation solutions for offshore wind turbines. They can be roughly divided into seabed foundations and floating solutions.

Seabed foundations include piled, gravity-based and tripod foundations, the most common type of which is the piled foundation. While the different foundation solutions have their limitations regarding seabed quality and depth, what they all have in common is that the structures are anchored to the seabed.

Floating foundations, which are mainly anchored to the seabed using cables, have also been developed for wind turbines. As their name suggests, the power plants float on the surface of the sea. Power plants with floating foundations can be placed in deeper water areas that those with foundations on the seabed, and the depth on the site must be at least 60 metres. However, floating power plants are a relatively new technological solution, and their feasibility has its own problems. In the Gulf of Bothnia the ice creates specific difficult conditions, and in their current development phase, using floating power plants in challenging ice conditions presents problems.

Electricity transmission solutions and their placement

Offshore wind farms essentially include wind turbines located on the production site at sea, cables within the production site, offshore substations and possible transmission cables from the production site to onshore electricity infrastructure.

Each offshore wind farm needs an offshore substation for electricity transmission purposes. Cables connect each turbine on the production site to the offshore substation. The substation consists either of a switchgear that assembles cables of equal voltage from different turbines and feeds the power downstream, or a transformer substation where transformers are used to convert the generated electricity into the form in which it can be transmitted to the mainland. The required voltage depends on the selected cable technology; this determines the voltage that the transformers will produce and whether the electricity will be transmitted as DC or AC.

From the substation, the submarine cable transfers electricity along the bottom to an onshore substation. The transmission cables are laid along a prepared cable route on the seabed. On soft bottoms, it is also common to immerse the cables in the bottom sediment, for example by ploughing, and to protect them in shallower sections of the transmission route using such materials as rocks or concrete where the cable meets the land (Niras Consulting ltd. 2015). The cable-laying technique to be used depends on the topography and quality of the bottom.

Each production site needs at least one transmission cable to feed the energy downstream unless it is, for example, converted into hydrogen on the production site in the future. If several cables are used for electricity transmission at sea, the area affected by seabed interventions in connection with cable laying will grow.

When planning cable routes, the bottom quality and water depth as well as the ecological values and conservation status of the area must be taken into consideration. While ecological values can be considered in the alignment of the route, as a rule it must be as straight as possible. Due to technical challenges and environmental impacts, the aim is to avoid uneven seabed and the need for excavation. Other human activities in marine areas, including fishing and shipping, must also be accounted for in cable placement. Similarly, existing pipelines and cable routings with their safety distances must be taken into account. Wrecks to be protected and possible war-time explosives must additionally be considered in terms of cable routings. Consequently, cable routings have certain framework conditions that determine the placement of cables: the production site, electricity recipient, security of supply, other users of the sea area, social needs and environmental conditions.

3 Basic premises and conduct of the impact assessment

This chapter discusses the environmental impacts of offshore wind farms and their submarine cables as well as their assessment at a general level. In practice, the impacts of the production site and an individual cable routing depend on their precise locations and are assessed as part of the EIA and permit procedures.

The impacts of different functions and structures on the environment vary during the project's life cycle. Construction-phase impacts are different from those created during the operational or decommissioning stages. Traditionally, the impact assessment examines the permanence (temporal duration and reversibility), strength and direction of the changes caused by the activities (negative/positive) (Mäkelä & Salo 2023). The same breakdown of projects into different phases and the determination of impact types apply to different projects: power transmission cables and biogas plants, wind turbines, roads or onshore power lines alike.

Three alternative scenarios, or theoretical possibilities of implementing the plan, are specified and used as an assessment tool. As defined in the SEA Act, these scenarios are called implementation alternatives. One of them is the so-called 0 alternative, meaning that the plan does not go ahead at all. The other two alternative scenarios are based on the theoretical maximum implementation on all sites in accordance with the given framework conditions and a possible partial implementation scenario. The scenarios do not comment on the feasibility, likelihood or implementation schedule of any of the alternatives.

According to guidelines issued by the Finnish Environment Institute and the Ministry of the Environment (Mäkelä & Salo 2023), the impacts of anthropogenic activities on the environment may, for instance, be of the following types:

- negative or positive
- direct or indirect (secondary)
- cumulative
- permanent or temporary
- reversible or irreversible
- impacts manifesting over the short, medium and/or long term
- combined impacts.

When analysing the object of the impact, the sensitivity of the object is significant. It is determined on the basis of the following factors:

- the object’s ability to withstand negative changes (tolerance)
- the object’s ability to recover from changes (resilience)

- the object's importance, for example from the socio-economic or environmental perspective

Assessing the significance of the impact, which consists of the magnitude of the change and the sensitivity of the object, is also essential when assessing environmental impacts. In case of the marine environment, for example, certain species are more sensitive to change than others, the variety of small details or rare quality of certain habitats may make them more difficult to replace, and the presence of a certain natural resource may mean that an area is of national importance for some industry. The completed assessment report also describes the way in which the significance of an individual impact or object is determined.

This SEA assessment takes into account other plans, including offshore wind power projects in territorial waters. In offshore wind farm projects, the assessment of combined impacts also plays an important role due to the large size of the projects and the high total number of offshore wind power projects planned for the Gulf of Bothnia.

3.1 Examined implementation alternatives

The SEA assessment examines three implementation alternatives, based on which the assessment looks at alternative scenarios, seeking to identify significant impacts of the plan. While different scenarios are called implementation alternatives in the wording of the Act, at SEA level, the assessment in practice means analysing scenarios rather than evaluating feasibility.

By law, one of them is the so-called zero alternative, in which the plan or programme (in this case the draft decision) will not implemented or introduced at all. In this assessment, the zero alternative would mean that the sites would not be put out to tender or investments would not go ahead.

VE0

No offshore wind farms in the exclusive economic zone scenario

VE0, or the zero alternative of the environmental assessment, refers to a situation where no offshore wind farm investments will be made.

VE1

Partial implementation scenario

VE1 describes a situation in which offshore wind power projects are implemented on two out of the four designated sites, or Bothnian Bay North and Bothnian Sea West.

VE2

Maximum impact scenario

VE2 describes a situation in which offshore wind projects go ahead on each designated site.

Figure 4: SEA assessment scenarios and their three implementation alternatives (VE).

The partial implementation scenario (VE1) includes two of the four sites to be assessed, or Bothnian Bay North and Bothnian Sea West (see Figure 5). In this scenario, the sites were selected with the aim of assessing impacts and impact pathways that are as different as possible. The sites selected for the scenario differ from each other significantly in two ways: they are geographically far from each other in the north-south direction, and at different distances from the coast. Selecting sites that are geographically distant from each other for consideration highlights differences between the characteristics of the different sea areas. The sites' different distances from the coast bring up different impacts on the coast. In addition, a greater distance from the coast requires longer cable runs and consequently increases the impacts.

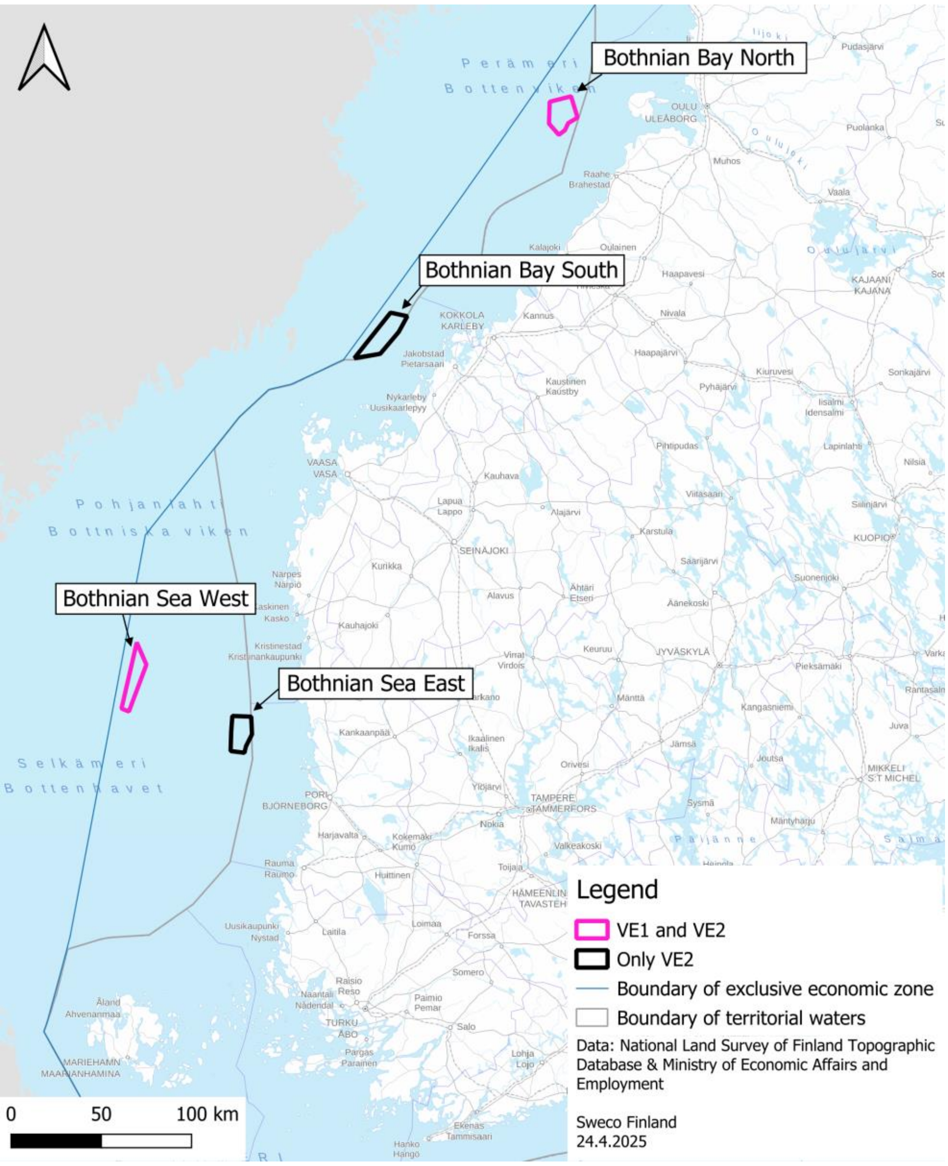


Figure 5: Sites to be assessed in the different scenarios. The partial implementation scenario (VE1) covers two out of the four sites, or Bothnian Bay North and Bothnian Sea West. The maximum impact scenario covers all four areas.

3.2 Identified impact pathways of offshore wind farms

3.2.1 Impact mechanisms and impact pathways

An impact refers to a change in the current state of the environment, which can be positive or negative. In order for the impact to be assessed, sufficient information must be obtained about the current state of the environment, the source of the impact, the impact mechanism, the object, and sensitivity of the object.

The SEA procedure is an ex-ante assessment based on existing environmental data in which the impacts are catalogued and assessed in general terms. The more detailed impacts of each offshore wind power project will be investigated later.

The impacts and impact pathways of offshore wind farms vary depending on the location of the production site and the project's life cycle stage. Among other things, the location of the production site determines which objects affected by the impacts there are in the impact area of the wind farm: the ecological values of the site and its location in relation to these values and other plans will enhance or mitigate the significance of the impact pathways.

The impact pathways of an offshore wind power project also vary during its life cycle: in the construction phase the pathways are different from those in the operational or decommissioning phases (see EIA programmes for offshore wind power projects in the exclusive economic zone). The intensity of the impacts also varies during the project life cycle: for example, the noise impacts are greater in the construction phase but of shorter duration than during the operational phase.

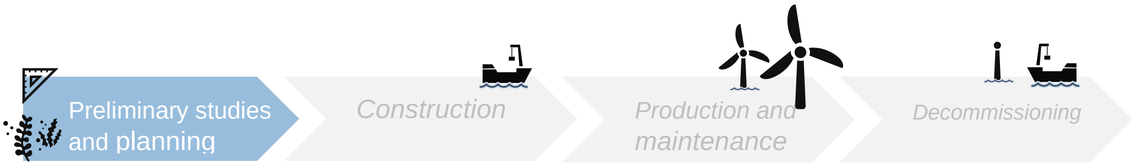
The impacts of each implementation alternative are described in more detail in the environmental report. The environmental report also deals with mitigating impacts.

3.2.2 Preliminary studies and planning

The impact pathways of the preliminary study and planning phase in the area under review arise from surveys and studies carried out on the production site and along cable routings. Some of them may comprise desktop studies based on existing data that have already been collected. However, offshore wind power projects require field studies and sampling on the project site to determine environmental impacts and to support the wind farm's technical planning.

Field studies mean more marine traffic in the area under review as it is depth sounded, its environment is surveyed, and the characteristics of the seabed are examined. Seabed surveys also interfere with the seabed as samples are collected and drilling required for foundation design takes place. Samples are additionally collected from the seabed to determine concentrations of harmful substances in the sediment (incl. heavy metals), making it possible to select disposal sites for the construction phase based on sediment quality.

The decisions and solutions made in this work phase will indirectly affect all other life cycle stages.



While the impacts of this phase itself are mild, decisions made during it will affect the environmental impacts of all other life cycle stages.

Key impact pathways identified for the phase:

- Disturbance caused by maritime traffic and surveys
    - Organisms move away or suffer from stress.
        - Birds, fish, marine mammals, invertebrates in underwater habitats

- Interference with the seabed when collecting samples and conducting studies
    - Highly localised destruction of benthic fauna and seabed habitat

3.2.3 Construction

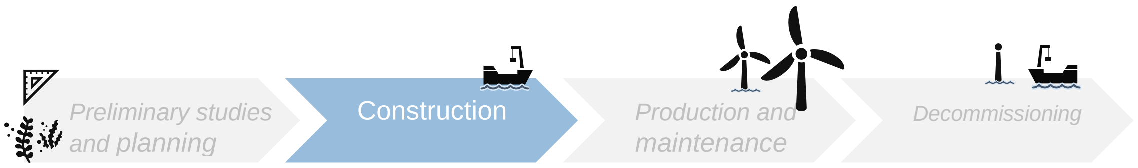
Construction period impacts are relatively short-lived but also intensive. Wind turbine construction and cable laying require significant volumes of marine traffic and seabed intervention. The construction phase produces the first permanent environmental changes of the project.

The seabed on the production site is prepared for building the foundations; the extent of this disturbance depends on the seabed quality and the chosen foundation technique. To construct the foundations, sediment may be removed by dredging, in which case the dredged sediment will be transported to disposal sites identified in the preliminary studies. Cable laying involves immersing the cable in soft sediments, whereas on hard bottoms separate protection methods of the cables may be necessary. On hard sediments, blasting may also be needed when building the foundations, and the same applies to cable laying if the bottom is uneven.

Depending on the selected solution, foundation construction involves piling, anchoring and casting as well as transport of foundation elements. Foundations that require piling or blasting cause short-term loud noise. During and after the construction of power plant foundations, noise and movement caused by construction and marine traffic will create disturbance. Increased marine traffic during the construction phase combined with localised temporary loss of benthos at the foundations may expose the offshore wind farm site to the spread of invasive species; no research evidence is available on this issue, however. (Bergström et al. 2021)

The construction-phase environmental impacts consequently stem from physical interventions in the seabed and disturbance caused by other construction work. Seabed intervention also causes the sediment to mix with the water column, which may result in the dissolution of contaminants in the sediment into the water and the release of nutrients into the water column for a short time. Benthic habitats at the foundations are destroyed. In terms of soil disposal and cable laying, impacts on the seabed in the construction phase are temporary.

The greatest sources of impact during the construction phase consequently are the construction of foundations and cable-laying, in connection of which the seabed is disturbed.



The impacts of this phase are powerful but short lived.

Key impact pathways identified for the phase:

- Disturbance caused by marine traffic, construction of wind turbines and cable laying:
  - Organisms move away or suffer from stress.
    - Birds, bats, fish, marine mammals, invertebrates in underwater habitats
  - Hearing damage caused by construction noise
    - Birds, fish, marine mammals
  - Potential spread of alien species

- Seabed interventions during construction of foundations and cable laying
  - Localised destruction of benthic habitat
  - Mixing of sediment nutrients with the water column
    - Deterioration of water quality
  - Dissolution of sediment contaminants in the water column
    - Deterioration of water quality, accumulation of harmful substances in biota

3.2.4 Production and maintenance

Compared to the construction phase, the impacts during the production and maintenance phase are spread over a longer period but their intensity is lower. The noise impact is an example of the difference in the duration and intensity of the impacts between the construction phase and the production phase: blasting noise during the construction phase is short and intensive, while the vibrations and humming of an operating wind turbine are less severe but long-term. As part of production and maintenance, power plants are serviced. In case of faults, it may also be necessary to repair power plants and cables, in which case spare parts are transported to the site requiring maintenance. In the event of a cable failure, the cable must be lifted from the seabed and repaired on a surface vessel. Marine traffic and repairs cause disturbance to the fauna in the area, and bottom sediment interventions may be necessary in connection with repairs, causing temporary disturbance to the benthic habitats and mixing sediment with the water column.

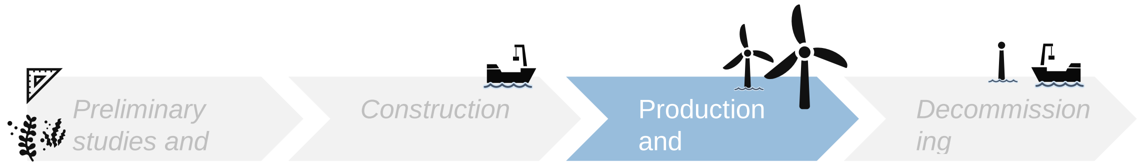
In the production phase, wind turbines generate constant noise, especially below the water level. Noise affects different organisms differently. In fish, for example, the impact depends on the species: some species are driven away by the wind turbine's noise and vibration, while others are attracted to the foundations of offshore wind farms in open water areas. It should be noted that waves also cause continuous natural underwater noise.

While there is no marine traffic on the offshore wind power production site under normal conditions, in an emergency ships may navigate between wind turbines. Offshore wind farms prevent trawling on the production site and also bottom trawling along cable routes. In practice, the production site provides an area for fish and benthic animals where they are protected from trawling. As bottom trawling is discontinued, this may reduce the mixing of sediment with the water column on the production site.

Hard underwater structures of wind turbines and protective structures for cables may also create new habitats for species of hard bottoms; this is called the artificial reef effect (Bergström et al. 2021 & Vehanen et al. 2010). The strength of the reef effect is influenced by such factors as the diversity and scale of the structures (Vehanen et al. 2010).

Wind turbine structures also affect currents and sea state, which in turn may have an impact on biota. Currents have a direct impact on microalgae, which in turn affect other organisms both directly and indirectly as part of the food web.

While there is no noise from operational cables, a magnetic field is created around them which may affect magnetosensitive fish species, including migrating eels and benthos close to the cable. Studies show that eel migrations are not prevented but may be slowed down (Niras Consulting ltd 2015). Any sediment covering the cables weakens the magnetic field and its extent in the water column. While the service life of the cable is around 40 years, the risk of disruptions and repairs increases after approx. 10 years of use. In other words, seabed interventions after the construction phase are a special case (Niras Consulting ltd 2015). The impact of the installation depends on the habitats and organisms of the installation site and seabed characteristics.



While the impacts of this phase are long-lasting, they are weaker than in the construction phase.

Key impact pathways identified for the phase:

- Operation and maintenance of wind turbines:
  - Wind turbine flicker and noise
    - Disturb birds, bats and fish; the impact is species specific
  - Bird collisions with blades
  - New hard bottom habitat
  - Disturbance caused by maintenance
    - Organisms move away or suffer from stress
    - Intensity and objects depend on the measure

- Electromagnetic field created by cables
  - Slowing down of fish migrations
  - Magnetosensitive benthic animals are driven away or decline

- Impacts of power plant structures on other anthropogenic activities
  - Prevention of fishing
    - Protection zone for fish
  - Barrier to navigation
    - Reduction of noise from shipping
  - Interference caused by wind turbine structures hampers radar use

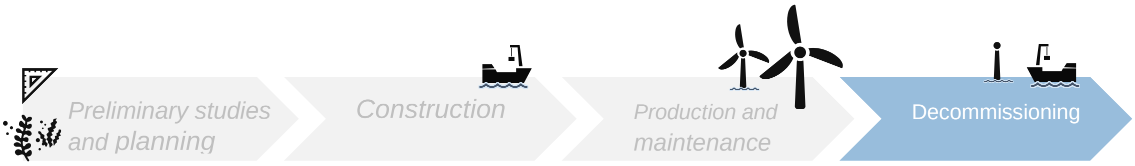
3.2.5 Decommissioning

When the power plant ceases to operate, its structures will be demolished, making it possible to take the production site into other uses and giving ecological values a possibility to recover. At minimum, the wind turbine structures above sea level are dismantled, and underwater structures are removed sufficiently to make the area available for navigation. Concrete obligations to dismantle offshore wind turbines in Finland's exclusive economic zone have as yet not been laid down in legislation, and no case-law on this matter exists in Finland.

Decommissioning causes disturbance to biota through dismantling operations and increased marine traffic. Depending on the scale of the demolition measures, for example if the wind turbine foundations are removed, the activities result in interference with the seabed comparable to the construction phase. At this stage, dredging and soil disposal are unlikely to be necessary.

The dismantling of the foundations may have greater impacts on the environment than leaving them at the bottom, as long as it is ensured that no harmful substances dissolve in water from the foundation structures.

In addition to demolition, this life cycle stage also includes any restoration measures aimed at promoting the recovery of ecological values in the impact area of the wind park, as well as monitoring of the state of the environment.



The impacts of this phase are similar to the construction phase but weaker.

Key impact pathways identified for the phase:

- If structures are removed completely
  - The hard bottom habitat created during the operational stage around the foundations and protective structures of cables will be destroyed and species will be lost.
  - The noise from demolition work causes disturbance to biota, especially underwater.
  - When a cable is removed, sediment is mixed in the water column; nutrients and contaminants in the sediment are dissolved in water.
  - The environment recovers close to its original state

- If the structures are removed to a depth that enables navigation
  - Disturbance caused by demolition work drives away animals, especially birds and fish.
  - The hard bottom habitat created around the foundations and protection structures for cables is preserved.
  - The environment does not recover to its original state.
  - Bottom trawling will not be possible on the production site.

- After demolition, the disturbance caused by noise and flicker by the wind turbines and the bird collision risk are eliminated.

- Electromagnetic fields generated by cables disappear.

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