Pleione energy farm

Documentation for notification pursuant to Article 3 of the Espoo Convention

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Administrative tasks

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About the notification

The Espoo Convention on Environmental impact assessment in a transboundary context is an environmental protection convention for Europe, Canada and the United States concerning cooperation to prevent transboundary environmental effects.

Under the Espoo Convention, the party of origin for an activity with a potential transboundary impact is required to inform and invite interested parties (that is to say other countries) likely to be affected by the activity to participate in the environmental impact assessment procedure.

This notification is designed to provide an overall description of the project, the project area and a preliminary report on the scope and content of the future environmental impact assessment, which specifically addresses expected transboundary impacts.

Summary

Pleione Energipark AB is owned by OX2 (publ) and Ingka Investments, a part of the Ingka Group.

OX2 AB (publ) is one of the leading players in large-scale wind power in Europe and the company is now planning to establish an energy farm, Pleione. The Energy Farm will be located in the Baltic Proper about 37 kilometres to the east of Gotland.

The farm area for the Pleione Energy Farm covers about 194 km^2 and is located in the Swedish economic zone (EEZ) about 40 km east of Gotland. The Pleione Energy Farm will consist of approximately 42–70 wind turbines and hydrogen plant(s) on specific platforms or on the bases of the wind turbines. The project will include related equipment as transformer/inverter stations and submarine cables.

The number of wind turbines built in the energy farm is governed by the size of the wind turbines. Larger wind turbines take up more space but offer higher output, while smaller turbines offer a lower output but occupy less space. The maximum overall height of the wind turbines is expected to be up to 370 metres.

The Pleione Energy Farm is expected to generate about 5 TWh of electricity per year, which corresponds to electricity consumption for up to 1 million households. The farm is expected to be operational by 2030.

The distance from the planned Pleione Energy Farm to the mainland of Latvia is about 103 km, the distance to Lithuania is about 166 km and the distance to the island of Saaremaa, which belongs to Estonia, is about 144 km. The distance to the Russian exclave of Kaliningrad is about 259 km, to Finland about 317 km, to Poland about 289 km and to Bornholm, which belongs to Denmark, is about 366 km. The distance to the mainland of Germany is about 507 km.

Under the Espoo Convention, the party of origin for an activity with a potential transboundary impact is required to inform and invite interested parties, that is to say other countries likely to be affected by the activity to participate in the environmental impact assessment (EIA) procedure. This notification is designed to provide an overall description of the project, the project area and a preliminary report on the scope and content of the future EIA which specifically addresses expected transboundary impacts.

The preliminary conclusions are that the impact, within the Swedish EEZ, of the planned activities is expected to be limited, which means that the potential transboundary impact can also be expected to be limited. A nautical risk analysis will be developed because of the increased risk of collision for shipping, due to the obstruction factor created by the wind turbines and also an increased risk of accident linked to the production of hydrogen. Regarding possible effects on birds, further studies will be carried out during 2023 and the impact on birds will then be described in the upcoming environmental impact assessment.

Contents

Concepts and definitions

To make it easier for the reader, specific concepts and definitions have been compiled, to be used when describing the planned activities and for the project's preconditions and expected environmental impacts.

Connection Corridor	The area or areas within which the energy farm's export cables and export pipelines to one or more land connection points are located.
Export cables	Electrical cables that transfer the electricity generated by the energy and wind farms to one or more connection points on land.
Export pipelines	Pipelines that transfer hydrogen gas produced by the energy farm to one or more land connection points.
Output	The speed of energy conversion. Production capacity is measured in kilowatts (kW) and their multiple units; 1,000 kW = 1 megawatt (MW), 1,000 MW = 1 gigawatt (GW), 1,000 GW = 1 terawatt (TW).
Energy	The product of output and time. Energy produced is measured in kilowatt hours (kWh) and its multiple units; 1,000 kWh = 1 megawatt-hour (MWh), 1,000 MWh = 1 gigawatt-hour (GWh),1,000 GWh = 1 terawatt-hour (TWh).
Energy farm	Wind turbines, plant parts for hydrogen production, inter-array cables, internal pipeline network, transformer and inverter stations, met masts, and related parts within the Pleione project area.
Halocline	A boundary between water masses with two different levels of salinity. The difference in salinity between surface water and bottom water creates a layering that makes it difficult to mix the different layers.
Inter-array	Internal electrical cable network within the energy farm.
Internal pipeline network	Network of internal pipelines for the transport of hydrogen within the energy farm.
Environmental impact assessment (EIA)	A document attached to the application for a permit. It must describe the direct and indirect environmental impact on human health and the environment and allow an overall assessment of the consequences arising from the planned activities.
Farm area	The area in which the energy farm is planned, bounded by the coordinates that are shown in Figure 1.
The Seveso legislation	The Seveso legislation includes the Act (1999:381), the Ordinance (2015:236) and the Regulations (MSBFS 2015:8) on measures to prevent and limit the consequences of serious chemical accidents, as well as the Environmental Code (1998:808) and the Act on the Protection against accidents (2003:778)
Mitigation measures	Mitigation measures are measures taken to avoid and minimise adverse environmental impact.

Sweden’s economic zone	The Swedish economic zone is located where the maritime territorial border in the sea does not reach the boundary agreed with the neighbouring countries concerned.
Territorial waters	Sweden’s territorial waters consist of the waters located outside the baseline to 12 nautical miles from the baseline.
Overall height:	The total height of the turbine up to the blade tip when it is at the highest position over the sea surface.

1. Background

1.1 About OX2

OX2 AB (publ.) (below OX2) is one of Europe's largest wind power companies and develops, builds and sells large-scale renewable energy solutions. OX2 also offers wind and solar farm management after completion. OX2s development portfolio consists of both proprietary and acquired projects in different phases in onshore and offshore wind, solar and energy storage. On 19 May 2023, the Swedish government granted a permit for Galene, one of OX2's offshore wind farms in the Kattegat, within the Swedish economic zone. The company is also active in technology development linked to renewable energy sources, such as hydrogen. OX2 has operations in eleven markets in Europe and has been operating in Australia since 2023. In 2022, OX2's sales revenues amounted to approximately SEK 7.6 billion. The company has approximately 500 employees and its head quarter in Stockholm. OX2 has been listed on Nasdaq Stockholm since spring 2022.

Ingka Investments, the investments arm of Ingka Group, which operates 392 IKEA stores in 32 markets has a clear focus on investments in renewable energy. In addition to covering its own consumption, Ingka Investments also wants to be able to reduce its climate footprint in the entire value chain. Ingka Group has an installed capacity of renewable energy of more than 2.3 GW, which corresponds to the annual consumption of more than 1.25 million European households.

OX2's business objective is to accelerate the transition toward a fossil-free energy system with a net positive impact on natural capital by 2030. The aim is therefore that the wind, solar and energy farms OX2 develops, and builds should create as much climate benefit as possible, while protecting or strengthening biodiversity through the projects. OX2's goal, in line with its business objective, is to establish nature-positive wind farms by 2030 that contribute positively to both climate change and biodiversity.

1.2 Pleione

Pleione Energipark AB, subsidiary of OX2 (publ.), is now planning to establish the Pleione Energy Farm. The farm area is located in the Baltic Proper, 37 kilometres east of Gotland, within Sweden's economic zone. This location is designated according to the SWEREF99TM coordinate system shown in Figure 1.

The planned area is approximately 194 km^2. When completed, the energy farm will include 42–70 wind turbines with a total height of a maximum of 370 metres and with rotor diameters of between 240 and 340 metres. The farm is expected to have an installed capacity of approximately 1.0 GW and generate approximately 5 TWh renewable energy per year.

The planned energy production would also enable production of approximately 120,000 tonnes of hydrogen per year and around 965,000 tonnes of oxygen per year.

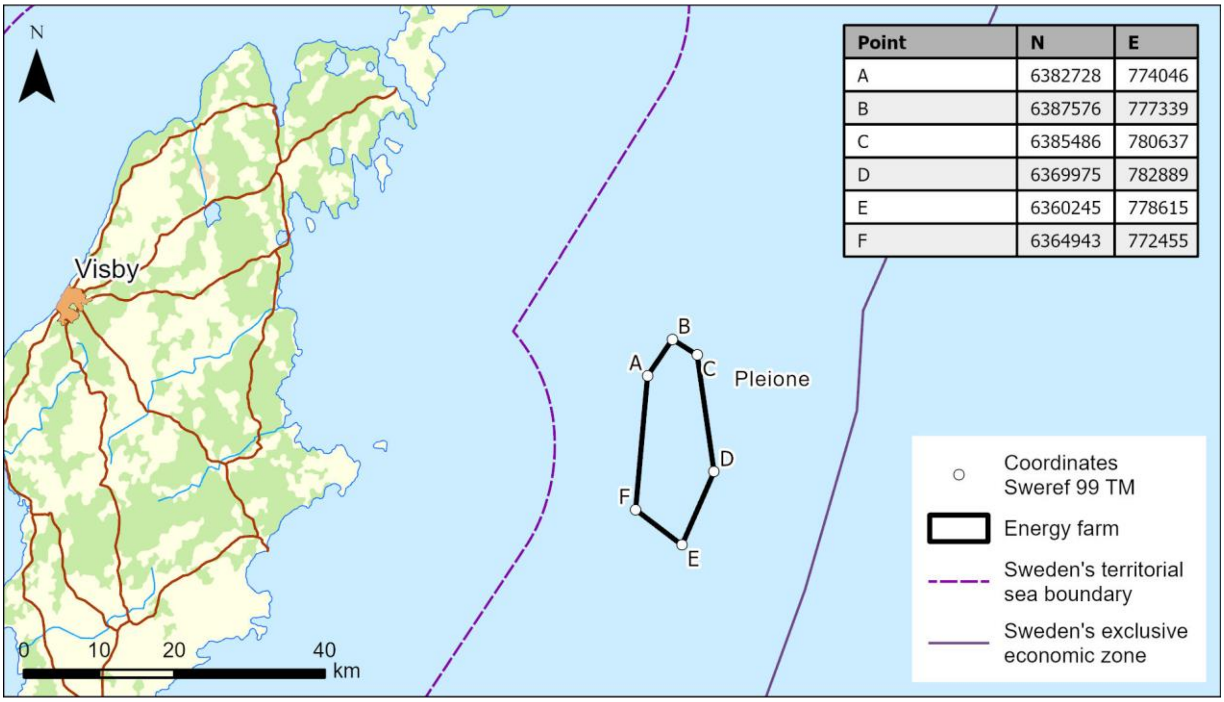

Figure 1. Coordinates of the farm's corner points. Base map: © [National Land Survey] 2023

1.3 About the need for fossil-free energy

The planned energy farm is part of the extensive energy transition in both Sweden and the rest of Europe from fossil-dependent power sources to energy production entirely based on fossil-free, green and sustainable technologies. In addition to environmental and climate goals driving technology development and investment in renewable energy sources, there is also a great need for new and fossil-free electricity generation to be established quickly and at a cost that generates competitive electricity. The demand for electricity is expected to be at least 300 TWh by 2045, which is twice the current electricity consumption.

1.3.1 Offshore wind power

Offshore wind power off the coast of southern and central Sweden has a great potential to contribute renewable electricity while at the same time making efficient use of existing electricity grids. This location also strengthens the area's ability to supply itself and create energy stability as the area currently has Sweden's lowest level of local production of electricity (Lara et al., 2021).

Compared to onshore wind farms, offshore wind farms can be built using larger turbines with higher power output. The conditions are also more beneficial for offshore wind power because wind speeds are higher and the winds blow more evenly, which contributes to more stable and efficient energy production. Offshore wind power can also be used for the production of hydrogen that can be used for industry, vehicles and transport, energy storage for electricity grids and also as energy carriers in further processing into other e-fuels.

1.3.2 Hydrogen

Hydrogen can be produced in a number of ways. Most current hydrogen production uses methods that give rise to greenhouse gas emissions (European Commission, 2020; Lara et al., 2021). Hydrogen produced by electrolysis powered by renewable energy is, however. completely fossil-free. Fossil-free hydrogen will be crucial for the climate transition in industrial uses, shipping and agriculture that cannot be electrified.

Hydrogen also has the advantage that it can serve to store energy. Wind, solar and wave power are intermittent in nature, which means that production varies over time. Under favourable conditions, the electricity generated may show a surplus, while under less favourable conditions enough electricity to meet demand may not be produced. Intermediate storage, for example by converting to hydrogen, is an alternative to wasting such surplus electricity. Gaseous energy carriers, such as hydrogen, can have an important part to play, through their energy storage capacity, in balancing an electrical system powered by renewable energy sources (Lara et al., 2021).

The development of technical solutions for energy conversion has gained momentum in Sweden and the rest of the world. The European Commission has set a target capacity in the EU of electrolysers for renewable hydrogen production with an output of at least 6 gigawatts by 2024 and 40 gigawatts by 2030. This will make hydrogen into an important part of a future energy system.

2. Permit processes

The Pleione Energy Farm requires several permits that are described in more detail in the sections below.

2.1 Permit for the construction and operation of the energy farm

The Pleione Energy Farm is located in Sweden's economic zone where the Swedish Economic Zone Act (1992:1140) (EEZ) applies. The application under SEZ is reviewed by the government. The energy farm therefore requires a permit pursuant to Section 5 of SEZ for the construction and operation of wind turbines and associated plants, including equipment for the production and storage of hydrogen and oxygen.

2.2 Permits for the laying the inter-array

A permit for laying the inter-array cable network and internal hydrogen pipeline network within the Pleione Energy Farm is required in accordance with Section 3 of the Continental Shelf Act (1966:314) (KSL), which is being reviewed by the government.

2.3 Natura 2000 permit

Activities or actions that could significantly affect the environment in a Natura 2000 area require a so-called Natura 2000 requires a permit under Chapter 7, Section 28a of the Environmental Code. Due to the distance between Pleione and existing Natura 2000 areas, the planned energy farm is not considered to have a significant impact on any existing Natura 2000 areas. It is therefore the view of Pleione Energipark AB that a Natura 2000 license does not need to be applied for with regard to existing Natura 2000 areas.

A request for the designation of a new Natura 2000 area along the east coast of Gotland has been handed over to the government. If the area is designated, the company will apply for a Natura 2000 permit.

2.4 Seveso legislation

Hydrogen production from the energy farm prompts questions under the Act (1999:381)) on measures to prevent and limit the consequences of serious chemical accidents (Seveso Act). SEZ refers to the provisions of the Environmental Code on consultation under the Seveso legislation. This consultation therefore also covers the requirements for the prevention and mitigation of the consequences of serious chemical accidents resulting from the activities laid down in the Seveso legislation. Pleione Energipark AB will thus include Seveso consultations in its upcoming SEZ application and associated environmental impact assessment.

2.5 Summary

Figure 2 below shows the permits required for the Pleione Energy Farm.

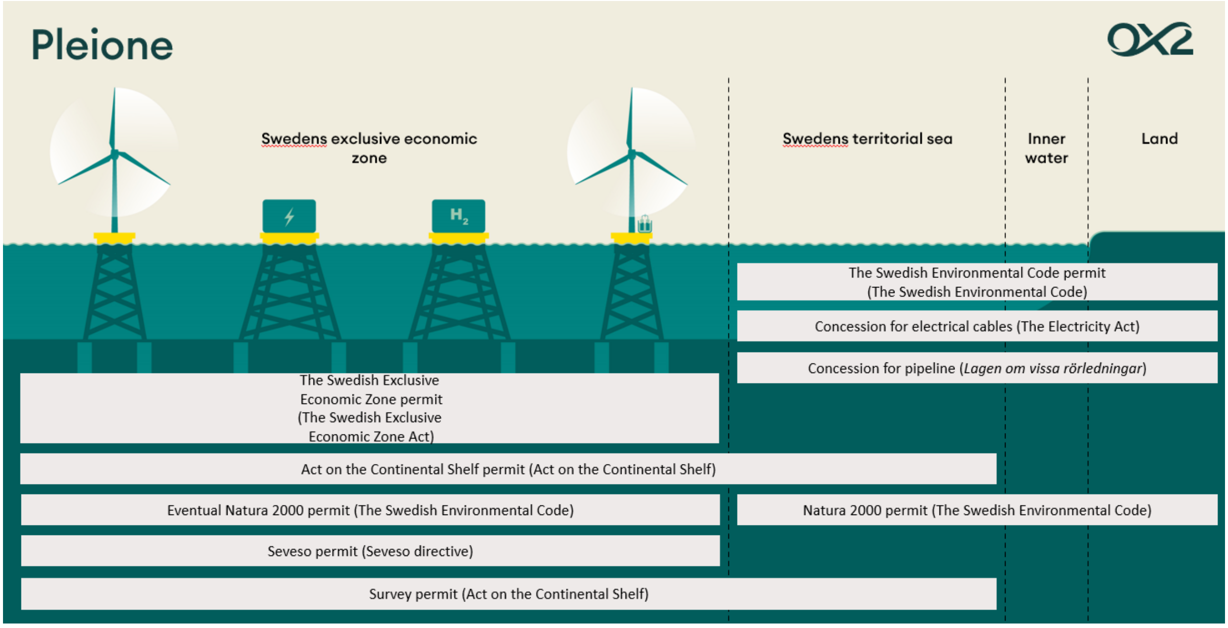

Figure 2. Illustration of what permits are needed for the Pleione Energy Farm. Illustrator: Nina Fylkegård

3. Activity description

3.1 Location

Pleione Energy Farm is located in the Eastern Gotland Basin in the Baltic Proper, see Figure 3. The area consists of open sea and has no islands. Pleione is located about 37 kilometres east of Gotland, within Sweden's economic zone and is about 194 km^2 in area. The water depth in the farm area varies between 30-140 metres.

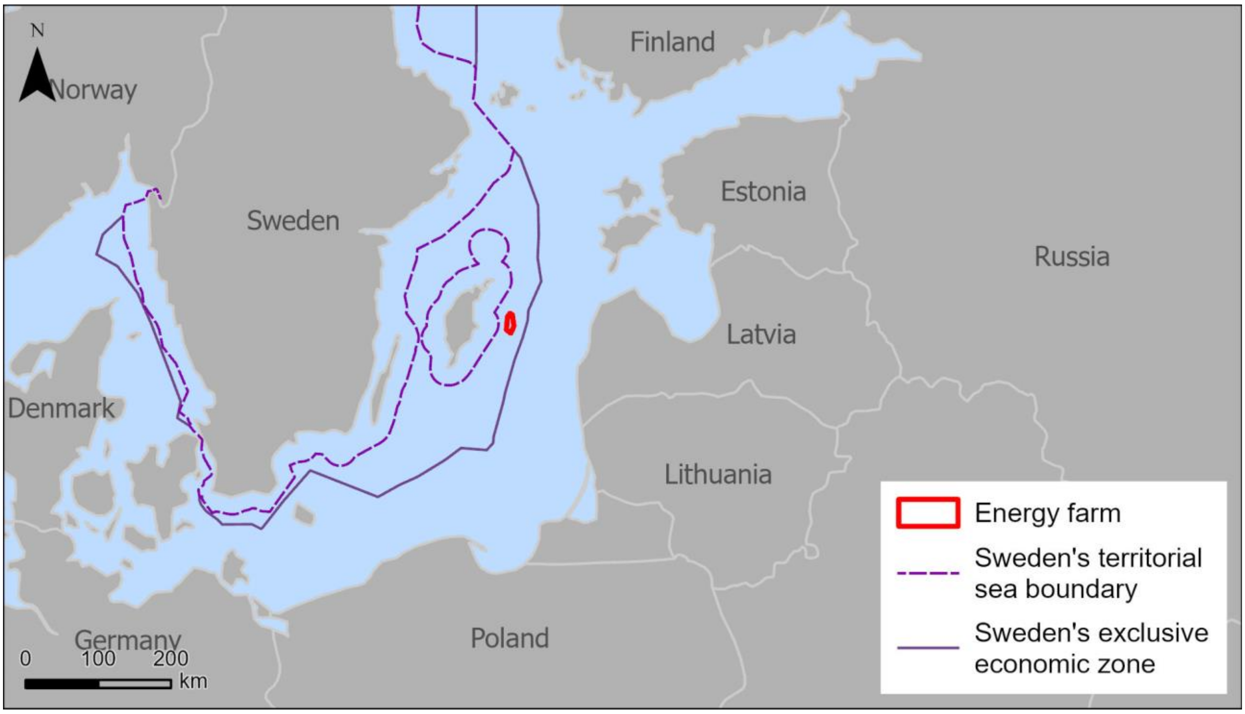

Figure 3. The energy farm's location in relation to surrounding countries. Base map: © [Natural Earth] 2023

The distance from the planned Pleione Energy Farm to the mainland of Latvia is about 103 km, the distance to Lithuania is about 166 km and the distance to the island of Saaremaa, which belongs to Estonia, is about 144 km. The distance to the Russian exclave of Kaliningrad is about 259 km, to Finland about 317 km, to Poland about 289 km and to Bornholm, which belongs to Denmark, is about 366 km. The distance to Germany is about 507 km.

The Pleione Energy Farm is expected to have favourable conditions for the establishment of wind power with an average wind speed of about 9.25 m/s (at an altitude of 150 m above sea level) (New European Wind Atlas, 2023).

3.2 The energy farm's design and extent

Table 1 below is a summary of Pleione's design and extent.

Table 1. A summary of Pleione's design and extent.

Name	Pleione
Size	194 km^2
Number of turbines	42–70
Hydrogen production	Yes
Base types	Seabed foundations and floating

The Pleione Energy Farm will include of two primary parts, wind power generation and hydrogen production. The farm will include approximately 42–70 wind turbines, depending on the size of the turbines and have an installed capacity of 1040–1050 MW. Up to 100 percent of the wind turbines' total capacity may be used for hydrogen production. The distribution between the farm's electricity and hydrogen production will be determined during the detailed design.

The wind turbines are anchored to bases and connected to an inter-array cable network. The inter-array connects the wind turbines to transformer or inverter stations, which are used to export the electricity to land, either as alternating current (substations) or as direct current (substations and inverters).

Figure 4 presents possible farm layouts in the farm area, using 15 MW and 25 MW wind turbines respectively. The layouts show how the farm could be designed. These are only examples of layouts and that the final design may look different.

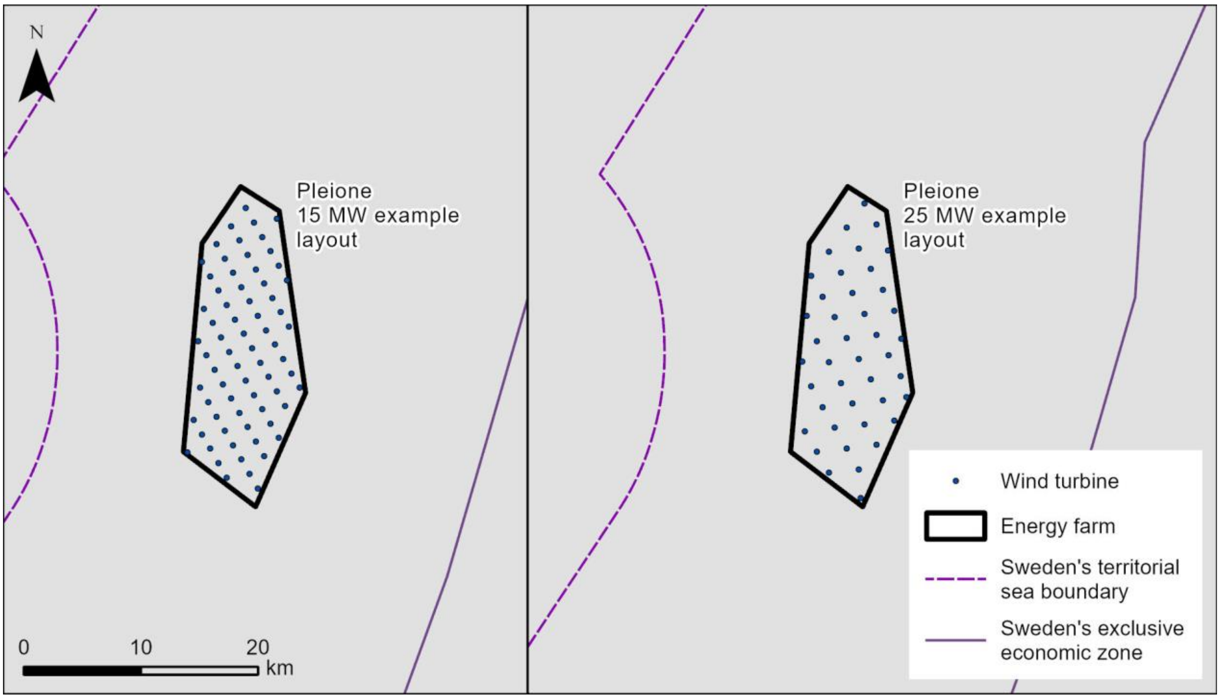

Figure 4. An example of possible farm layouts for the Pleione farm area, with 15 MW wind turbines on the left and 25 MW wind turbines on the right. Base map: © Sjöfartsverket

Energy storage and/or energy conversion platforms may also be built at the Pleione Energy Farm. The planned method for hydrogen production is electrolysis. The final number of electrolysers in the farm area will, among other things, depend on the technology solution chosen, the volume of hydrogen production and technological developments. Figure 5 depicts an outline sketch of the various parts that the energy farm will be made up of.

In addition, one or more masts may be installed for meteorological measurements or LiDAR, i.e. Light Detection and Ranging, as well as buoys for wave and current measurements.

Figure 5. Outline diagram showing the different constituent parts that an energy farm (centralised layout) generally consists of. Illustrator: Tobias Green.

3.2.1 Wind turbines

A wind turbine consists of a tower, nacelle and rotor blades and is installed on a foundation anchored to the seabed. The tower also contains electrical components. The main components of the nacelle are the gearbox, generator and yaw motors. A transformer will either be fitted in the nacelle or in the tower. The electricity produced by each wind turbine is transferred via an inter-array cable network to a transformer/inverter station. The farm may consist of several transformer/inverter stations depending on their design and capacity.

The wind turbines in the energy farm will most likely be a traditional model with three blades on a horizontal shaft, see Figure 6. The rotor diameter is expected to be between 240 and 340 metres and the maximum overall height of the wind turbine is expected to be 370 metres above sea level. The distance between the tip of the blade and the surface of the water will be about 30 metres.

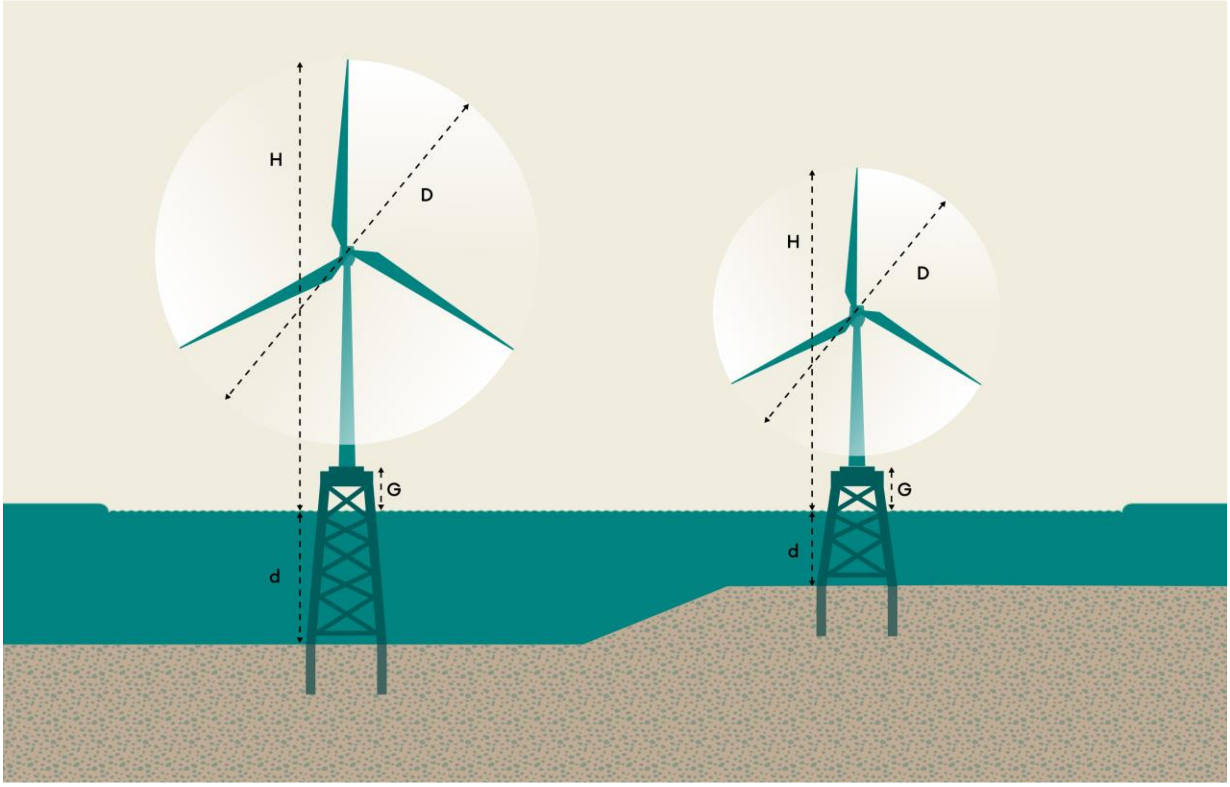

Figure 6. Examples of wind turbines. D = rotor diameter, H = overall height, G = clearance, d = water depth. Illustration: Fredrik Folkesson

The turbines are expected to produce electricity at wind speeds from about 3 m/s and achieve maximum production at wind speeds between 10 and 14 m/s. When the wind speed exceeds about 30 m/s, the turbine is automatically switched off to restart automatically when the wind speed is lower.

The wind turbines, including met masts, will have warning marking for air and shipping in accordance with current regulations, including the Swedish Transport Agency's regulations and general advice on marking objects that may pose a danger to aviation and on the notification of flight obstacles (TSFS 2020:88).

Additional maritime safety markings may be required, depending on the location of the energy farm in relation to shipping routes and lanes, e.g. pursuant to the Swedish Transport Agency's regulations and general advice on the marking at sea with maritime safety devices (TSFS 2017:66). The wind turbines may also be equipped with radar, mist and fog horns and an automatic identification system. In addition, a dialogue will be held with the relevant authorities on the necessary safety-enhancing measures.

3.2.2 Foundations

Foundations will be needed at the Pleione Energy Farm to attach platforms and wind turbines to the seabed. The choice of foundations depends on several factors: Primary water depth, geology, wind and wave conditions, and environmental considerations and costs. As both water depth and geological conditions vary within the farm area, different types of fixed or floating foundations may be considered in different combinations. The foundation types and installation procedure for hydrogen production and transformer/inverter platforms are similar to those for the wind turbines, but are dimensioned with respect to the loads resulting from the platform's needs. The following is a brief account of the different types of fixed and floating foundations that are deemed to be relevant.

Based on the geological conditions at the area and the technology available today, both fixed seabed foundations and floating foundations are relevant for the Pleione Energy Farm. The rapid developments in technology mean that other types of foundations may also be used.

Seabed foundations

Fixed foundations consist of three main parts; A part that secures the foundation in or on the seabed, a part to elevate above the surface of the water and a so-called transition piece that forms the transition between the foundation and the tower to ensure that the tower stands vertically. In connection with the foundations, erosion protection is provided on the seabed to protect the foundation from the formation of erosion holes around the foundation. The need for erosion protection varies depending on waves, currents and the type of bottom sediment. The most common type of erosion protection is layers of rock, gravel and sand of varying sizes that are laid around the base of the foundation and this can create reef structures that increase biodiversity, also known as nature-included design. Seabed foundations and their erosion protection also form artificial reefs. In collaboration with Blått Centrum Gotland, OX2 plans conducting pilot tests at Pleione, in which artificial reefs made of concrete will be laid out in the farm area. This is to see whether they attract cod and other types of fish. In addition, OX2 and Ecopelag have also collaborated in the development of a concept for large-scale blue mussel farming in offshore wind farms.

Of the seabed foundations, monopiles and jacket foundations with piles are mainly relevant for the farm, see illustrations of these in Figure 7. The foundations will be anchored to the seabed, usually by piling. Foundations that are fixed to the seabed may also use so-called suction buckets.

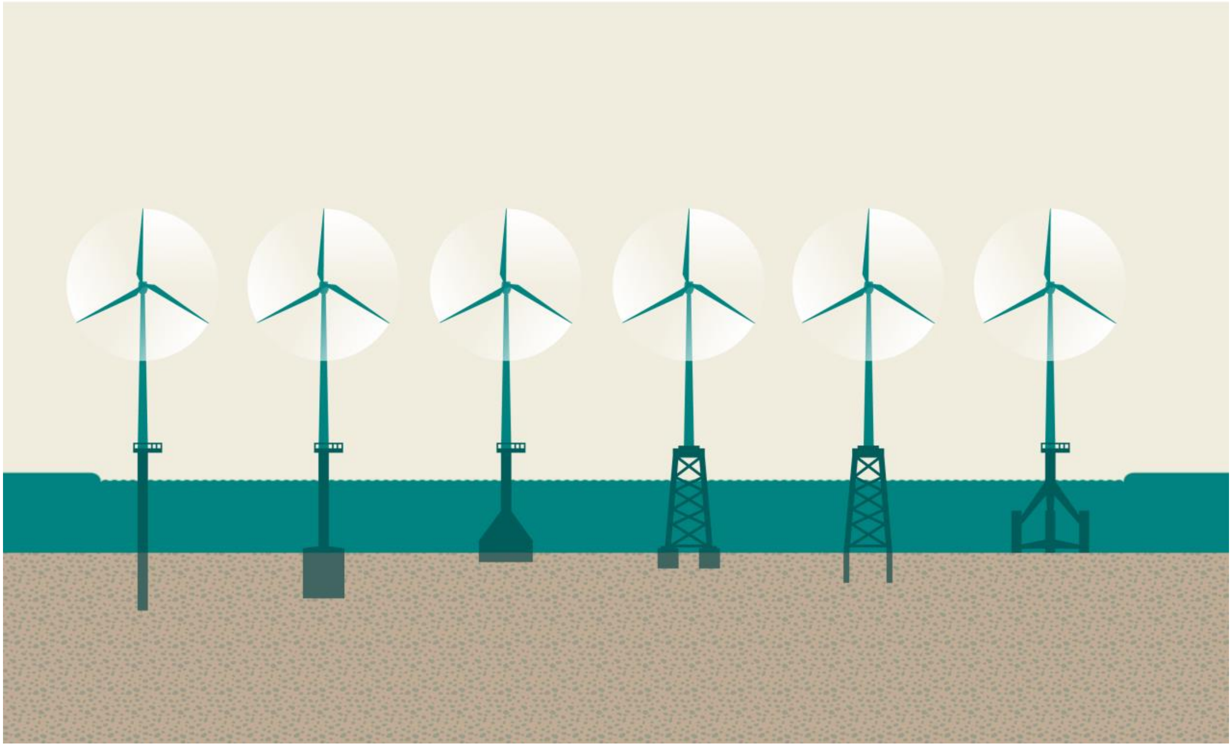

Figure 7. Foundations from left to right: Monopile, monopile with suction buckets, gravity foundation, jacket foundation with suction buckets, jacket foundation with pin piles and tripod foundation with pin piles. Illustrations: Fredrik Folkesson.

Floating base

A technology that is under development and is expected to be undergo rapid development in the near future, is that of floating foundations. The technology enables installations at greater water depths.

There are various variants of floating foundations, which can be divided into four categories. Spar, barge and semi-submersible floating are three variants of large foundations that are anchored to the seabed by means of long chains or tie-rods that are moored in some form by anchors. The fourth variant, tension leg platform, has a smaller platform and is anchored to the seabed with vertical running lines. This technology requires very strong tethering lines and a solid anchorage device on the seabed. See floating foundations illustrated in Figure 8.

Of the floating foundation solutions, semi-submersible foundations are currently considered to be most suitable for the greater depths of the Pleione Energy Farm, but neither spar nor tension leg can be excluded.

All floating foundations need to be anchored to the seabed using long lines/chains. All floating foundations have three to six anchor tethers. One tether line on each turbine is equipped with an "in-line tensioner" in order to adjust the tension on the tether. Tethering solutions that use an anchor that needs to be slightly buried in the seabed for attachment place higher demands on bottom conditions. Gravity anchoring is the technology that is least dependent on the bottom conditions, but the disadvantage of this variant is that it requires extensive use of materials for its manufacture. If necessary, erosion protection is provided around the anchor points.

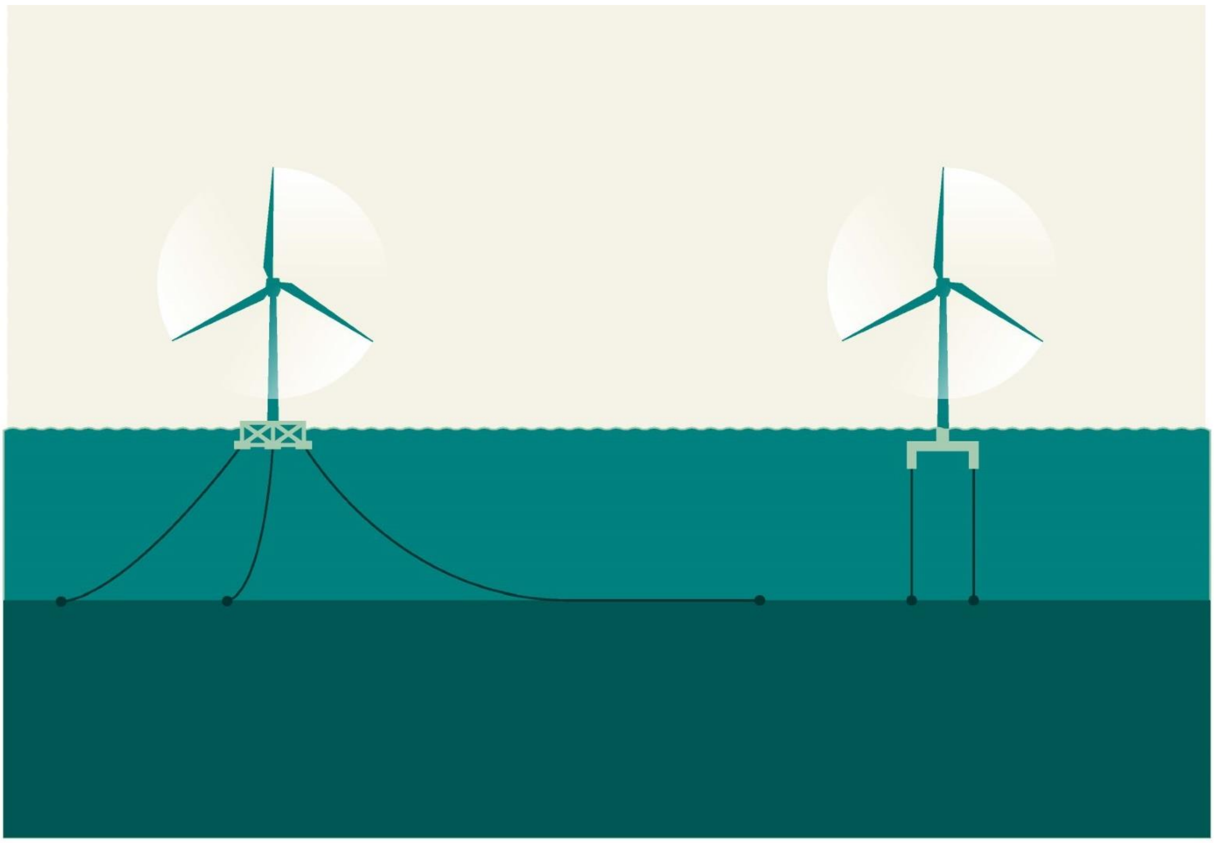

Figure 8. On the left side of the figure is a semi-submersible floating foundation with long anchor lines to the seabed. To the right of the figure is the tension leg platform variant that is anchored to the bottom with vertical tie down lines. Illustrator: Tobias Green.

3.2.3 Inter-array

The inter-array connects the wind turbines to the transformer/inverter stations, (offshore substations, "OSS") by connecting individual wind turbines in groups (radials), which in their turn are then connected to the respective transformer/inverter station.

For example, based on the cabling technology available today, the inter-array can consist of 66 kV cables, which can transmit a combined power of around 80-90 MW per cable. This means that up to six 15 MW turbines can be connected along the same radial. The voltage level of the mains supply cables is expected to rise to approximately 170 kV in the next five to ten years. This would increase the total transmission capacity of each cable, thus reducing the number of radials and thereby the total length of cables. In addition to the cables connecting the wind turbines, additional cables may be established within the energy farm to provide redundancy in the system and power supply to any platforms.

If floating foundations are used, the inter-array is made up of two types of cables, dynamic and static cables. The dynamic cable is a loose hanging part of the cable between the floating foundation and the seabed. Due to the movement of the floating foundations, the connecting cables need to be designed to accommodate such movement. The cable usually has a "lazy wave" design which allows it to be shaped and moved in harmony with the foundation, see Figure 9. The dynamic cable usually connects to a static cable on the seabed that can be buried in the seabed for protection, see Figure 10. In turn, that connects to a seabed transformer station.

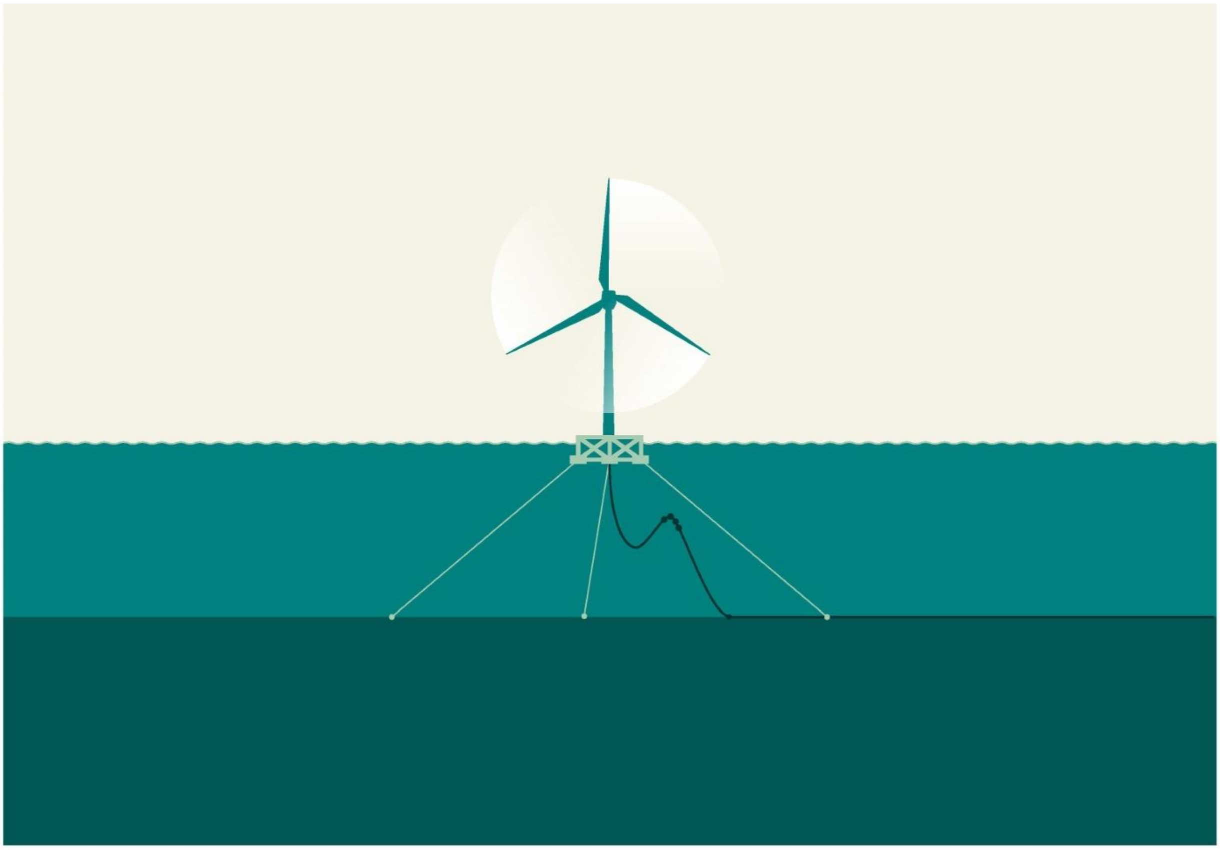

Figure 9. Floating foundation connected with a dynamic cable to accommodate the movement of the foundation. Illustrator: Tobias Green.

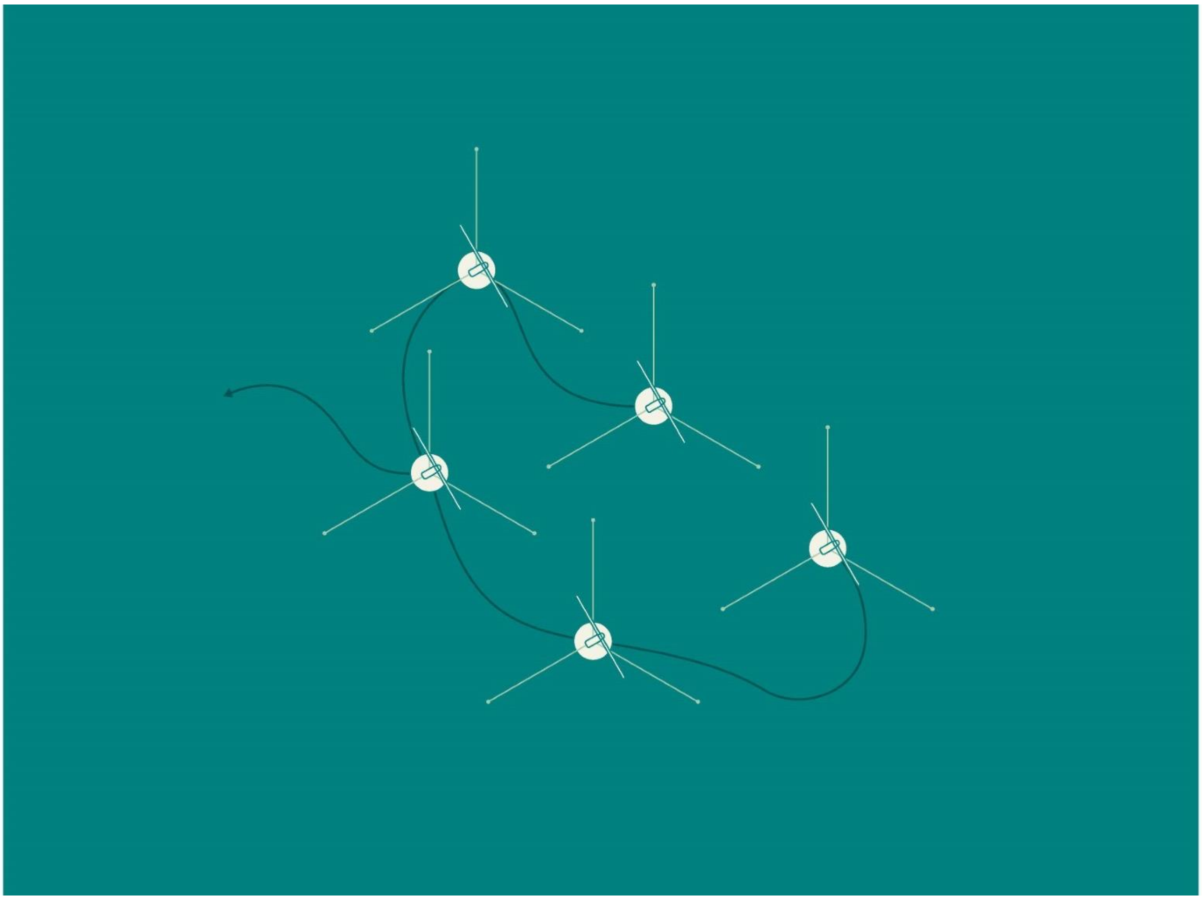

Figure 10. Top view showing how the turbines with associated tether lines can be connected via the inter-array cables. Illustrator: Tobias Green

3.2.4 Platforms

Within the farm area, one or more transformer/inverter stations are installed to which the electricity generated by the wind turbines is led via the internal cable array. Connection cables that export the electricity are run to shore connection points from the transformer/inverter station. The transformer/inverter station contains electrical equipment, including transformers that transform the voltage from the internal cable array to higher voltages. If the shore connection is made with direct current, inverters are also included as part of the electrical equipment. These stations are usually referred to as inverter stations.

The transformer/inverter station is a platform with one or more decks, sometimes with a landing pad for helicopters. The platforms are prefabricated and installed in modules on one or more foundations. Self-floating and self-installing platforms may also be relevant for the farm area.

If hydrogen production in the Pleione Energy Farm is carried out according to a decentralised concept, see section 3.2.6. a collector/compressor station will be needed to connect the internal pipeline network together and possibly increase the gas pressure. The collector/compressor station will need its own platform. If hydrogen production in the Pleione Energy Farm takes place according to the centralised concept, see section 3.2.6, specific platforms will instead be needed for hydrogen production. A large system of electrolysers will be installed on these platforms. See Figure 11 for some examples of how the platform and foundations can be designed.

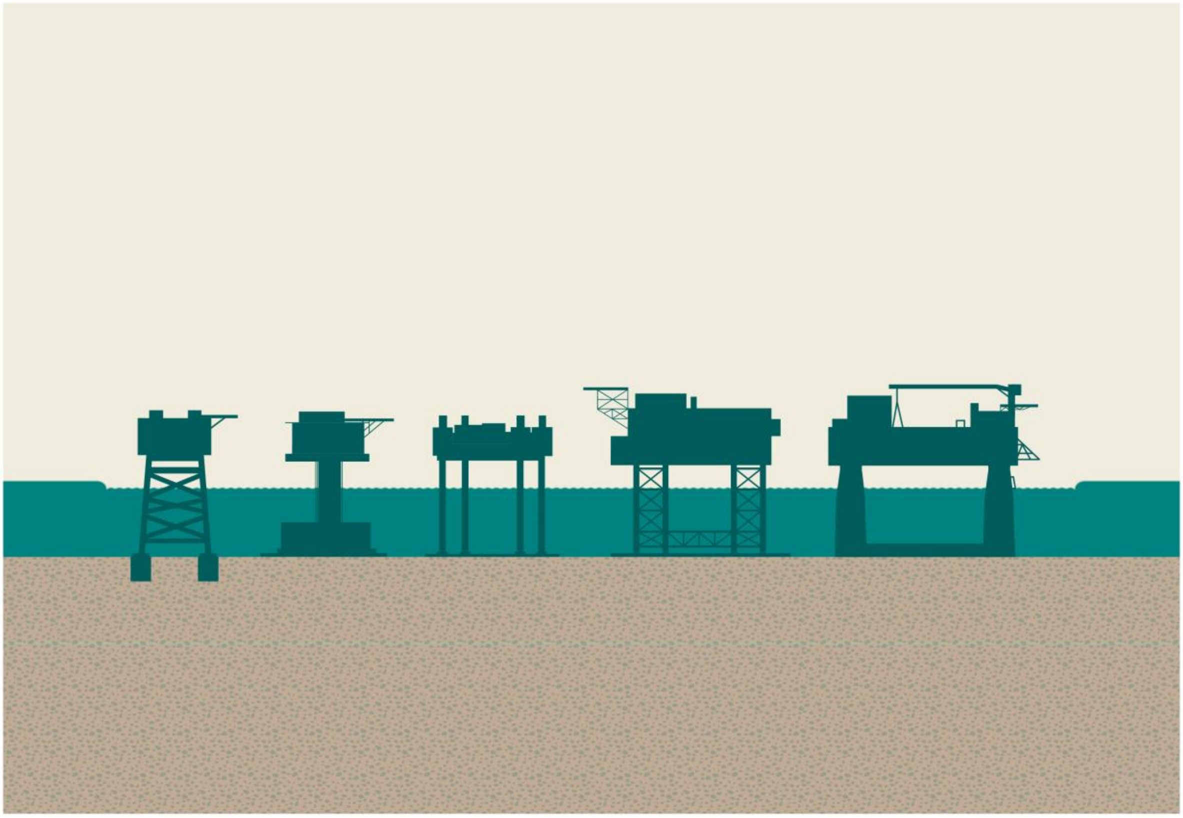

Figure 11. Examples of offshore transformer/inverter stations/hydrogen stations and their foundations. From the left: jacket foundation, gravity foundation, support leg foundation, jacket foundation (with float-over installation), self-installing gravity foundation.

The exact number, design and location of the platforms will be determined during the energy farm's detailed engineering process, based on the size and number of turbines, seabed conditions and optimal cable routing. There will be a maximum number of four platforms for the Pleione Energy Farm. The platforms will be marked in accordance with the applicable regulations for marine and air traffic.

3.2.5 Measurement of meteorological parameters

One or more met masts may be installed to supplement available wind data from the area and form the basis for detailed design and choice of turbines and their layout. A met mast usually has a height roughly corresponding to the hub height of the wind turbine and is installed in the same way as a wind turbine with a foundation anchored to the seabed. The foundation for a met mast is considerably smaller than for a wind turbine.

Data from the met masts can also be used to monitor the conditions for different lifts during installation, where there may be requirements for maximum wind speeds. The data can be used later in the process to monitor the energy farm's production. In addition, data from met masts concerning wind speed, turbulence and gusts, etc., can also be used as a basis for load calculations. Load calculations are performed when dimensioning the turbine, turbine tower, foundation and anchoring.

A technology that is rapidly developing and has the potential to replace met masts is called LiDAR. LiDAR technology uses lasers to measure wind speeds above sea level and thus does not require a mast. The equipment can be placed either on a fixed foundation or on a floating platform. At present, this measurement technique has not been certified to provide a basis for load calculations, but this is expected to be possible in the future.

3.2.6 Hydrogen production

Hydrogen production is planned within the Pleione Energy Farm. An energy conversion plant for hydrogen production can convert electrical energy from the wind turbines into hydrogen, see outline diagram in Figure 12. The electricity produced by the wind turbines drives electrolysers that split water (H_2O) into hydrogen (H_2) and oxygen (O). Desalinated seawater is used in the splitting process, which requires desalination systems that remove the salt (NaCl). The hydrogen produced can be used for industrial purposes or in the transport sector as well as an energy carrier.

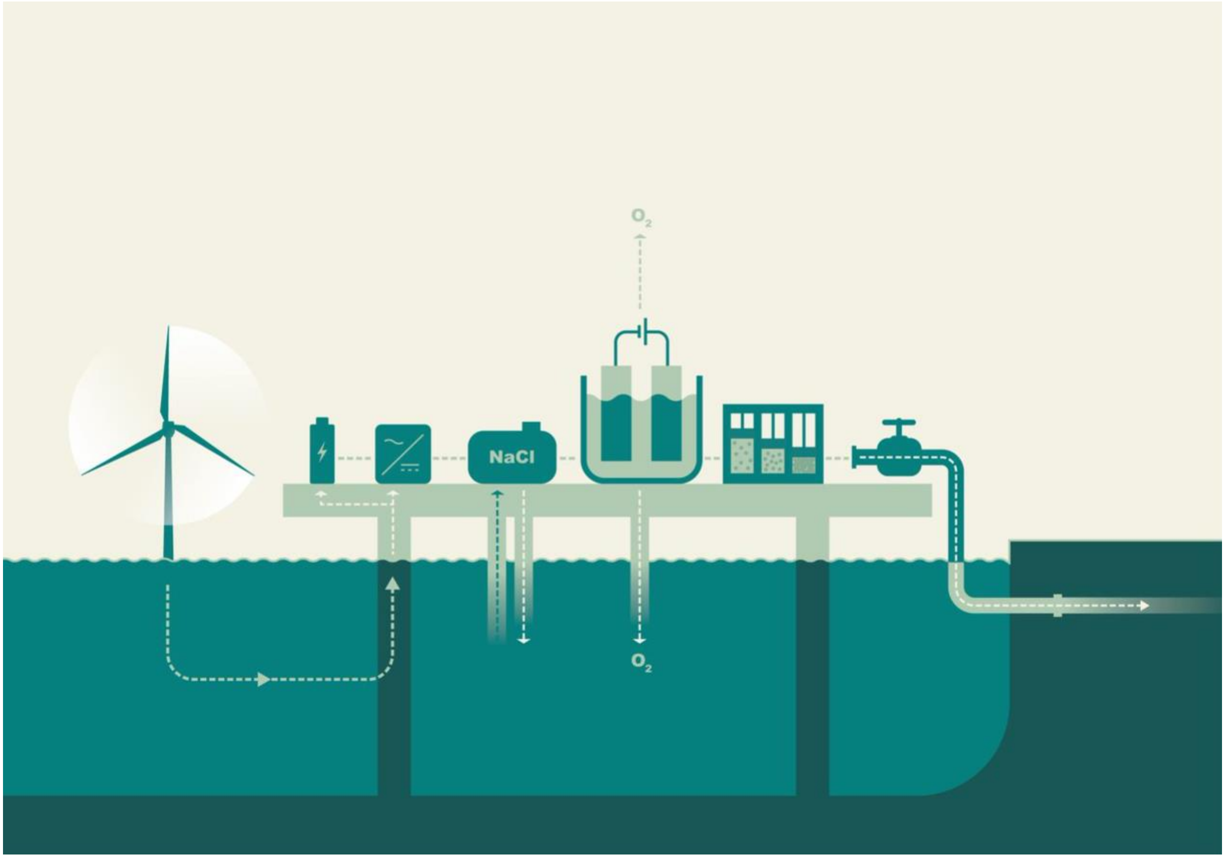

Figure 12. Illustration of hydrogen production. Illustrator: Nina Fylkegård.

There are currently several different technologies for producing hydrogen with electricity, the technologies that are considered to be most relevant for the Pleione Energy Farm are summarised in Table 2.

Table 2. Techniques for using electricity to produce hydrogen.

Technique	Benefit	Disadvantage
PEM (Polymer Electrolyte Membrane)	The production/load can be changed within seconds. High pressure from the electrolysers. Wide working area. Suits wind turbines' variable production.	Not as proven as alkaline water electrolysis.
Alkaline electrolysis	Proven and established technique.	Caustic soda is used. Low pressure.
SOEC (Solid oxide electrolyser cell)	Insufficient knowledge of the technique at present.	Insufficient knowledge of the technique at present.
AEM (Anion exchange membrane)	Insufficient knowledge of the technique at present.	Insufficient knowledge of the technique at present.

Hydrogen production using PEM electrolysers has at this consultation stage been considered to be the most suitable technology to investigate further, partly because it suits wind power's variable production. Hydrogen is then produced using electrolysis, either directly on the respective wind turbine foundations (decentralised hydrogen production) or on specific platforms within the farm (centralized hydrogen production). See these two concepts illustrated in Figure 13.

Electrolysis can also take place in an onshore facility. Onshore production of hydrogen gas may be an option in some cases. Depending on the electricity grid demand at the time, a portion of the wind turbine output from the farm can be used for hydrogen production. This is not currently being investigated for the Pleione Energy Farm, but the option is not excluded in view of potential future technological developments. In addition to all direct uses of hydrogen, there are more possibilities for replacing fossil products by using hydrogen. Under the so-called PTX technology, captured carbon dioxide or nitrogen gas from the air can be used together with green hydrogen gas via chemical processes to produce renewable fuels, fertilisers, etc.

When hydrogen is produced in an offshore electrolyser, oxygen, cooling water and brine are produced in addition to hydrogen. The volumes of hydrogen, oxygen, cooling water and brine listed below are based on a scenario in which 100 % of the energy produced by the wind turbines in the Pleione Energy Farm is used to produce hydrogen. The energy farm is likely to produce a combination of electricity and hydrogen, and the volumes of hydrogen, oxygen, cooling water and brine produced will then be smaller than the scenario with maximum hydrogen production. Components for hydrogen production may need to be replaced and renewed during the life of the energy farm.

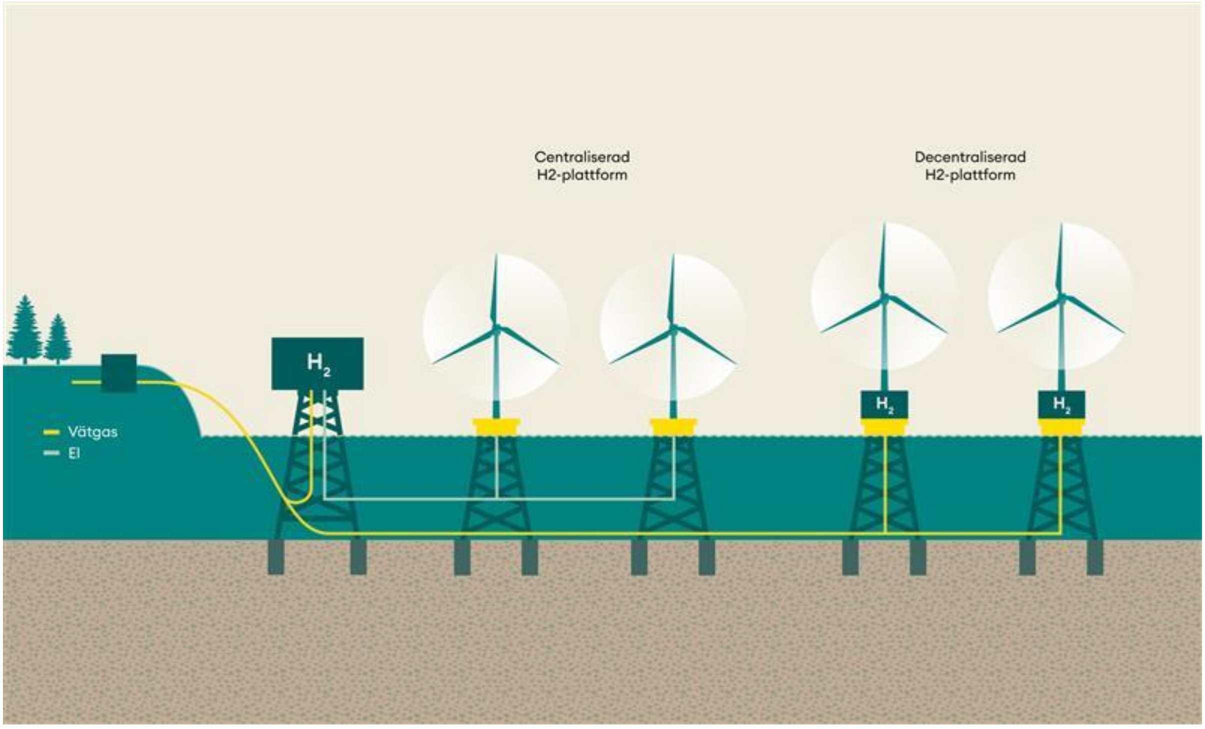

Figure 13. A schematic concept diagram linked to centralised hydrogen production (on the left) as well as to decentralised production (on the right). Illustrator: Nina Fylkegård.

Decentralised hydrogen production

Production of hydrogen using electrolysers on each wind turbine is called decentralised hydrogen production. Decentralised hydrogen production is the most energy-efficient way of producing hydrogen, but it is also a technology under development. The hydrogen produced at each wind turbine is routed via a pipeline system within the farm area to a collector/compressor station, which joins several pipelines to an export pipeline and raises the pressure, or to several export pipelines that transport the hydrogen into land. Once on land, for example, the hydrogen can be stored, transferred via a gas network or converted into e-fuel. In decentralised hydrogen production within the Pleione Energy Farm, with its associated compressors, electrolysers, buffer tanks and internal pipeline networks, a maximum of 30 tonnes of hydrogen will be in the system at the same time. In addition, a buffer tank containing 10 tonnes of hydrogen gas may be needed in connection with the compressor station. The hydrogen is transported from the compressor station via export pipelines onto the shore. Export pipelines will contain approximately 100 tonnes of hydrogen, which means a maximum storage volume of 140 tonnes of hydrogen.

Table 3. Compilation of momentary amounts of hydrogen in the Pleione Energy Farm with decentralised hydrogen production.

Internal pipeline network	30 tonnes
Buffer storage at compressor station	10 tonnes
Export pipeline	100 tonnes
Total, momentary stored hydrogen	**140 tonnes**

Centralised hydrogen production

In centralised production of hydrogen, the energy from the wind turbines is led electrically (AC cables) to one or more platforms within the farm area where the conversion from electricity to hydrogen takes place. The platforms together then comprise a larger system of electrolysers that can receive energy from multiple wind turbines, hence the name of centralised hydrogen production.

The platforms will also be equipped with all auxiliary systems for hydrogen production, such as a compressor station, which can then also contain a buffer tank for approximately 10 tonnes of hydrogen. The hydrogen is then transported from the platforms via export pipelines onto the shore. Export pipelines contain approximately 100 tonnes of hydrogen, which means a maximum storage volume of 110 tonnes of hydrogen.

Table 4. Compilation of momentary amounts of hydrogen in the Pleione Energy Farm with centralised hydrogen production.

Buffer storage at compressor station	10 tonnes
Export pipeline	100 tonnes
Total, momentary stored hydrogen	**110 tonnes**

Internal pipeline network

If hydrogen production is decentralised at the foundations of each wind turbine, an internal hydrogen pipeline network will be needed. The pipelines connect the wind turbines either in radials or in star formations to a collector station that connects all of the pipelines and compresses the hydrogen, making it at a higher pressure. The collector station can be placed on wind turbine foundation, a separate platform or on the seabed. The internal pipeline may follow the same routing as the inter-array. The exact routing is currently under further consideration.

Other things created by the hydrogen production

The production of hydrogen also produces brine, oxygen from the electrolysers and cooling water from the process, these are briefly described below. It should also be added that the levels indicated will vary depending on the size of the share of electricity generated by the Pleione Energy Farm that is used for hydrogen production. The values given below are based on a maximum design where 100 % of the electricity produced by the turbines in the Pleione Energy Farm is converted into hydrogen.

Brine

Desalinated seawater is used to split the molecules. The annual volume of sea water that the system needs to take in is up to 120 million tonnes. Sea water needs to be desalinated before it can be used to split the molecules. During desalination, the seawater is separated. The seawater in one part is desalinated by concentrating all the salt in the other part of the seawater ingested. This desalinates the first part of the sea water. The second part of the seawater intake will have a higher concentration of salt than it had at intake and is called brine. Most desalination plants for electrolysis in today's market produce 45-65 % desalinated water and 35-55 % brine. A lower percentage of brine means that the brine will be saltier and a higher percentage means that the brine will be less salty. The area where the seawater is taken in (depth and location) and where the brine is released can be chosen to create the most optimal conditions for the environment.

Oxygen

Oxygen is formed as a by-product when water molecules are split. Up to 965,000 million tonnes of oxygen is produced from the electrolysers per year, assuming that 100 % of the electricity generated in the Pleione Energy Farm is converted into hydrogen. Pleione Energipark AB is currently investigating the conditions for combining hydrogen production with an oxygenation stage, where oxygenated water is diverted to bottom waters. This is because there is a lack of oxygen in the Eastern Gotland Basin in the deep water below 80 metres depth. As a result, the company is investigating two alternative suitable positions for oxygenation in the Eastern Gotland Basin. The first option is that oxygen will be transported by a pipeline and released within the farm's eastern headland, where the water depth is about 145 metres. The second option is that oxygen from hydrogen production is routed outside the farm area and released about 20 kilometres away in an approximate east-north-east direction from the farm. Alternatively, the oxygen can be released to air as a gas or transported for use in other potential areas such as industry and healthcare. No storage of oxygen, beyond the 400 tonnes that are accommodated in the oxygen pipeline network, is planned for the operations.

Oxygenation of the Baltic Sea's oxygen-deficient bottom water has been shown in other experiments to potentially bind phosphorus but may also contribute to the re-colonisation of demersal animals, which in turn could stimulate fish production, see also section 6.3.7.

Cooling water

Cooling water is used to keep the system at an optimal operating temperature, mainly the electrolysers. At maximum hydrogen production, up to 120 million tonnes of seawater per year could be extracted from the sea to cool, for example, the electrolysers via a closed-circuit heat exchanger. During cooling, the cooling water heats and the outgoing cooling water is estimated to be approximately 15 °C warmer than the incoming cooling water. Other technologies are also being investigated, such as air cooling via cooling towers, as well as the possibility of optimising reuse of the heated coolant water in the desalination process, thereby also increasing the overall efficiency of the system.

3.2.7 Connection cables and connection pipelines

After electricity and hydrogen have been produced offshore, it will be exported to land via one or more connection corridors consisting of export cables and pipelines. Figure 14 shows possible onshore connection points for the export cables. Transport of hydrogen from the Pleione Energy Farm to land may also take place via operational gas pipelines to neighbouring countries in the Baltic Sea.

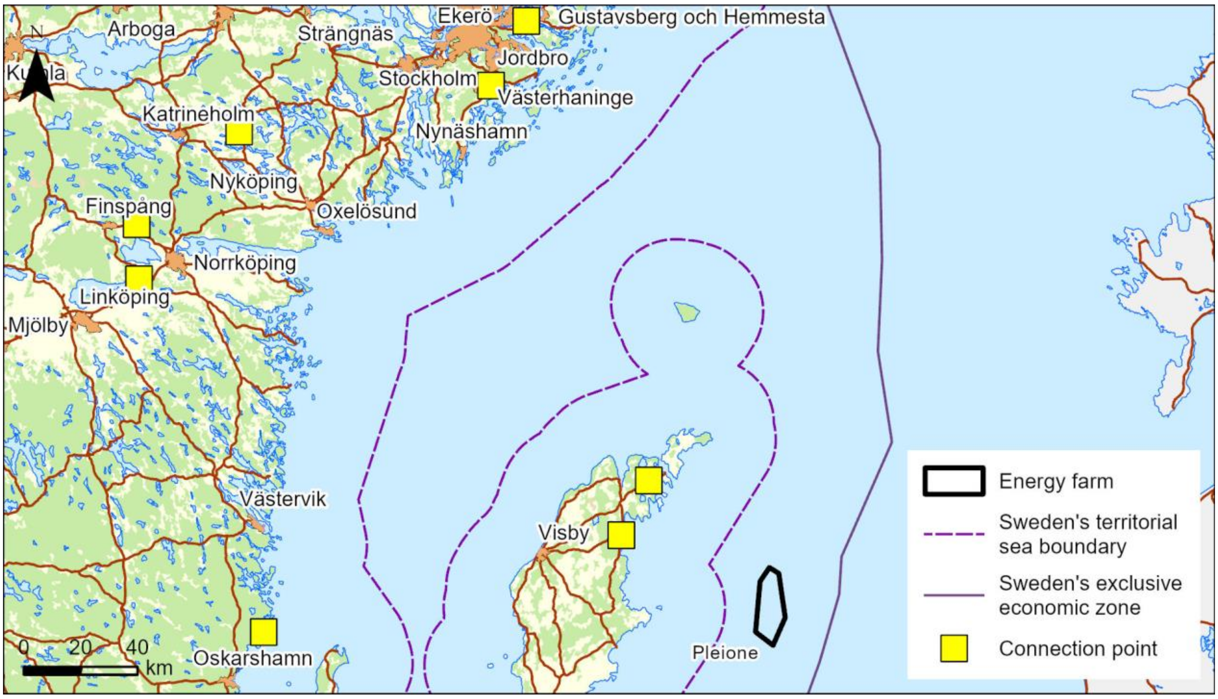

Figure 14. Connection points that may be relevant for connection to the farm. Base map: © [National Land Survey] 2021

3.2.8 Storage of hydrogen on land

The hydrogen from the Pleione Energy Farm may be stored in specially adapted facilities on land before it is transported to the end customer. Should it become relevant, a separate permit will be applied for in the required order.

3.2.9 Transport of hydrogen by vehicle

Transport of hydrogen from the potential onshore storage areas is most probable to take place by rail or road. If technological development simplifies the possibility of transporting hydrogen directly from the energy farm in specially adapted vessels, this option will be considered and has not been completely excluded.

3.3 Activities in the different phases of the project

This section summarises the activities planned during the construction, operation and decommissioning phases of the energy farm. Environmental impact assessments will be carried out for all three phases.

3.3.1 Construction phase:

The energy farm will be built over a period of several years The construction phase includes steps relating to prior preparation and installation of the farm.

Construction surveys

Prior to construction of the energy farm, inter-array and the internal pipeline network, site surveys of the seabed conditions will be carried out to study the geology and sediment of the seabed. The purpose of these surveys is to obtain detailed information for final design of foundations and the detailed design of the farm and cable and pipelines, including the exact location of wind turbines. Geophysical studies such as sidescan sonar (SSS) and multibeam echo soundings (MBES) well as various forms of seismic surveys, both 2D and 3D, provide high-resolution bathymetric information about the seabed sediment and its geological composition down to about 80 metres below the seabed. The investigations also provide information about the presence of natural and artificial objects on the seabed and any gas pockets.

Geotechnical surveys include geotechnical drilling, cone penetration testing (CPT) and vibrocores. Based on the results of these studies, the company can come to conclusions about, among other things, load-bearing capacity and thus design of foundations and choice of installation methods. Magnetometry is needed to ensure that construction work can be carried out without risk of, for example, finding mines or other unexploded ammunitions.

Installation

The following is a brief description of how to install a wind farm. In general, attempts are made to conduct installation works continuously during a single season and without interruption for winter.

The planned schedule for installation of the energy farm first installs the foundations, the transformer/inverter stations and hydrogen platforms, including their topside. The export connection to land, the inter-array cables and the internal pipeline network will then be installed. Finally, the wind turbines (including any hydrogen components for decentralised hydrogen production) will be assembled with the towers, nacelle and rotor blades. If floating foundations will be used in the Pleione Energy Farm, the wind turbine will be installed on the foundation in the assembly port, after which it is towed out to the energy farm and installed on site. Once the turbines have been fully installed, commissioning and operational trials take place before the facility is handed over to the operating organisation after approved tests.

Vessel traffic

During installation, the main components of the energy farm (wind turbines, transformer/inverter stations, platforms, met masts, foundations and any construction parts for the production, storage and distribution of hydrogen) must be transported to the respective areas, positioned and installed. The main components are shipped out of their respective manufacturing ports and transported either to a final assembly port, a pre-assembly harbour, or directly to the farm area.

Daily transportation of personnel and small components takes place from a nearby installation port. In addition to surface vessels, helicopters can also be used for transport.

During the installation of the energy farm, a number of installation vessels and working platforms of various kinds will operate in the area. Several support vessels may also be required for equipment and personnel, as well as tugs. All vessel traffic will be monitored by a so-called *marine coordinator*. A safety zone can be established around installation work in progress to minimise risks.

For some work, a jack-up vessel or a jack-up platform may be used, see Figure 15. These vessels lower their legs to rest on the seabed. The vessel's hull or platform itself is raised so that it is well above the highest wave height and therefore no longer affected by wave movements. As an alternative, semi-jack-up vessels can also be used. On semi-jack-up vessels, the hull remains afloat while the legs are lowered onto the seabed to ensure stability.

Figure 15. Installation of wind turbines by a jack-up vessel. Source: COWI

In addition to the above-mentioned vessels, additional special vessels may operate in the area, for example for various surveys or emergency operations. During construction there may also be one or more smaller boats that protect the installation area from other traffic.

Installation of foundations

Monopile foundations are floated out to the site or transported on board an installation vessel or a barge. Monopile foundations are placed on the seabed, either from a jack-up platform or from a floating crane vessel. The foundation is then driven down into the seabed by pile-driving, vibration-driving or drilling. Depending on the nature of the seabed, installation can take place using a combination of these methods.

Jacket foundations require the seabed to be relatively flat, which means that levelling may be required prior to installation. The foundation is transported to the site by a barge or installation vessel and placed on the seabed by a jack-up platform or a crane vessel. If pin piles are used the steel pipes are driven, vibrated or drilled into the seabed at the respective corners of the foundation. Pin piles are then attached to the foundation by concreting them together or by mechanical tethering. If geology and other conditions make it possible, jacket foundations can be anchored to the seabed using a suction caisson, a steel or concrete cylinder that is sucked into the seabed by means of a vacuum.

Floating foundations are towed out to the site, usually with a fully assembled turbine. The foundation is anchored in place using the same basic principles as for seabed foundations, except that different forms of buried anchors can be used.

Inter-array network and internal pipeline network

Before the installation of internal electrical cables and pipelines begins, preparatory work is carried out to ensure a safe and unobstructed laying process. The preparatory work includes clearing rocks and boulders on the seabed and removing foreign objects on the seabed such as fishing nets, lines, etc. Clearing involves a certain penetration of the seabed. It may also be necessary to level the seabed if there are sand dunes or other unavoidable, easily-moved seabed features, or in places where the bed is steep.

The pipelines and cables, rolled up on large coils, are transported to the farm area by special installation vessels. The cables and pipelines are laid on the seabed and then usually buried to a depth of between one to three metres below the seabed to protect the cables from damage from fishing gear, anchors, etc. When cables or pipelines are placed directly on the surface of the seabed, they can be protected by covering them with, for example, stone or concrete structures or by laying them in pipes.

If a cable or pipeline needs to cross an existing cable, pipeline or other existing infrastructure, both the existing and the new cable network must be protected. The protection can consist of concrete mattresses, steel or concrete bridges, for example. The details of this type of intersection are set out in a cable crossing agreement developed by the cable and/or pipeline owners.

Wind turbines

The main components of the wind turbines may be transported to the energy farm by the installation vessel or by a separate transport vessel. The components can be transported directly from a port near the wind turbine manufacturer or from an installation port. The various components are then installed using a crane, normally in a single working day if weather conditions permit.

Installation of wind turbines with fixed foundations will take place in turns out at sea. Installation of wind turbines requires high precision and is therefore restricted by wave and wind conditions. Once the wind turbines have been installed, the components can be connected to the inter-array and to the internal pipeline network (for decentralised hydrogen production), as the wind turbines are tested.

In the case of floating foundations, the wind turbine is installed on the foundation in the assembly port, after which it will be towed out to the Pleione Energy Farm. Port installation minimises the impact of such factors as wave and wind conditions.

Electrolysers

Electrolysers for hydrogen production will either be installed directly on the foundations of the wind turbines, at junctions or on separate platforms. Installation directly on the foundations of the wind turbines will be carried out after the turbine has been fully assembled.

Hydrogen production platforms are similar on the outside to transformer/inverter station platforms, although possibly larger. Due to the fact that the weight and surface requirements of the electrolysers are greater than those of the corresponding platforms, it is probably more appropriate to use larger platforms for hydrogen production in order to reduce the number of individual platforms in the Pleione Energy Farm.

Once installed, either on the foundations or platforms, the electrolysers are connected to the internal pipelines.

Transformer/inverter stations

A transformer/inverter station is normally installed on its base using a crane vessel. Depending on how the transformer/inverter stations and their foundations are designed, they can also be towed out or installed using other lifting methods, for example with their own legs. Alternatively, the foundation may be built first, after which the superstructure is lifted into place. When the transformer/inverter station has been installed, the inter-array electrical cables are connected to the station.

3.3.2 Operational phase

Wind turbines, transformer/inverter stations and plant components for the production, storage and distribution of hydrogen are remotely monitored and unmanned during normal operation. However, continual maintenance takes place at the farm, which requires personnel and materials to be transported there by supply vessel, ship or helicopter. Cables and pipelines are inspected as necessary to ensure, for example, that their protection at the base of the wind turbine is unchanged. If a cable is damaged it can be repaired by the damaged cable section being lifted by a cable-vessel to carry out the repair work, and then replaced onto the seabed using the same method as during the construction phase.

The final operating and maintenance strategy will be determined at a later stage. An onshore operation and service base is likely to be established. It is likely that maintenance work will be primarily carried out by Crew Transfer Vessels (CTVs) or by a larger Service Operation Vessel (SOV). Jack-up vessels may be used for more extensive maintenance operations, for example where large components need to be replaced.

3.3.3 Decommissioning phase

The energy farm is expected to have reached the end of its service life after 45 years' service, after which it will be decommissioned. Decommissioning will be carried out in accordance with the practice and legislation in force at the time of decommissioning. Wind turbines, foundations, transformer/inverter stations and plant components for the production, storage and distribution of hydrogen will be dismantled and foundation sites will be restored to the required extent.

The farm components will be dismantled unless the removal of these individual structures has a greater environmental impact than that of leaving them in place. As the technology and knowledge situation is changing rapidly, the detailed farm decommissioning will be suitably planned in consultation with the supervisory authority.

It is likely that the structures above the seabed surface will be decommissioned. For example, monopile or jacket foundations can be cut a few metres below the sea floor and the upper part lifted off. Floating foundations and associated wind turbines will be detached from their anchor lines/chains and then towed to port for recycling/scrapping. Some farm parts may be left behind after decommissioning, such as inter-array cabling and internal pipelines.

One reason for leaving some structures behind is that these may have become a part of valuable artificial reefs. If it is necessary to remove cables and/or pipelines they will be released from the seabed and lifted to the surface. Rock used to cover cables and/or pipelines is likely to be left on the seabed, as well as the protection used at intersections. During decommissioning, a temporary safety zone will be established around the location of activities to protect personnel, equipment and safety for third parties.

3.4 Preliminary schedule

The Pleione Energy Farm schedule is shown in Figure 16 below. Several factors may affect the schedule, which may require adjustment during the course of the work. The schedule should therefore be considered to be general and preliminary. The complete development of the energy farm is expected to take up to six years.

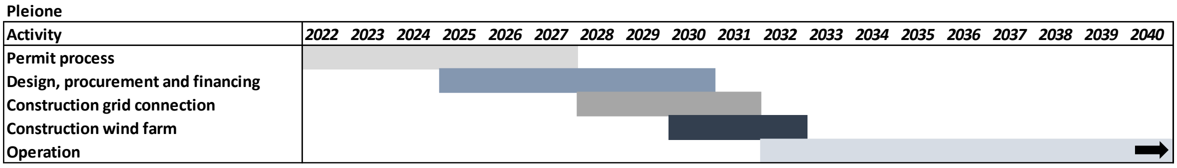

Figure 16. Preliminary farm schedule.

4. Area description

4.1 Geology and depth conditions

The Pleione Energy Farm is located about 37 kilometres east of Gotland, within Sweden's economic zone, outside the border for territorial waters. The water depth within the farm area varies between approximately 30 and 140 metres, with an average depth of approximately 79 metres (EMODnet, 2018), see Figure 17. The farm area contains no islands and only consists only of open sea.

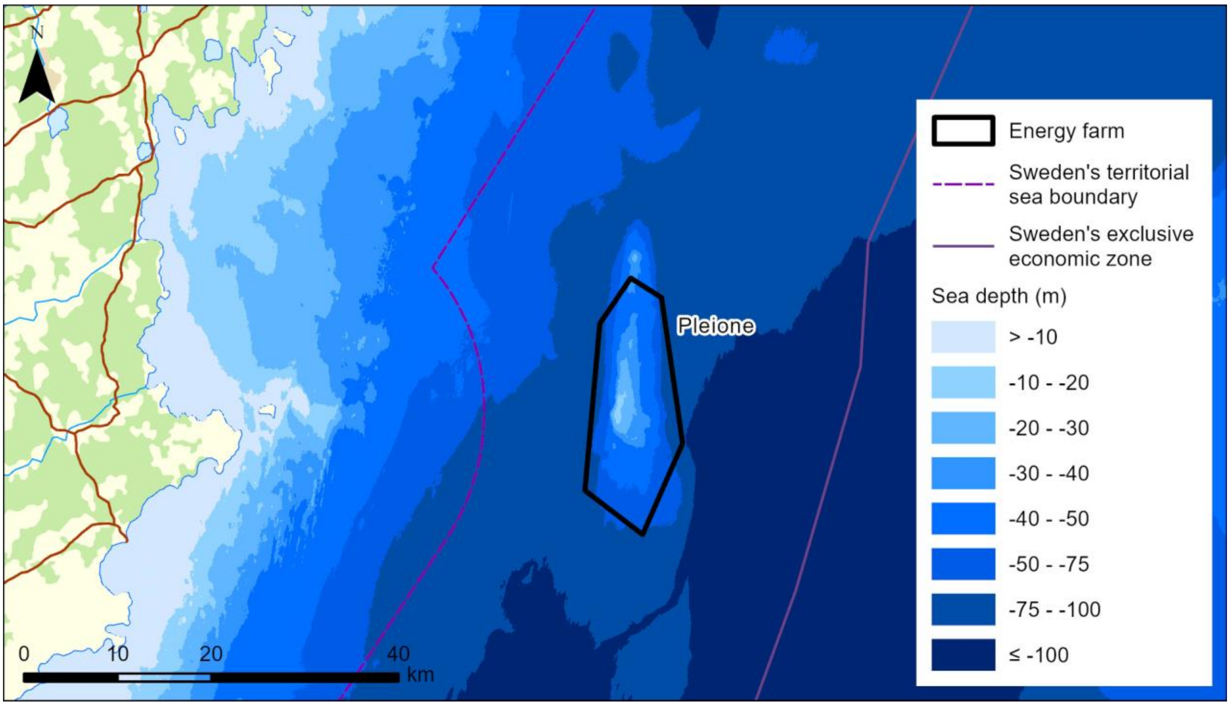

Figure 17. Depth conditions in the farm area. Base map: © [National Land Survey] 2022 [Document EMODnet]

According to available substrate layers from EMODnet, the bottom substrate consists largely of coarse substrate, as well as mixed sediment. The coarser substrate classes such as large rocks and blocks are more common at shallower depths (Didrikas & Tano, 2018)) (Figure 18).

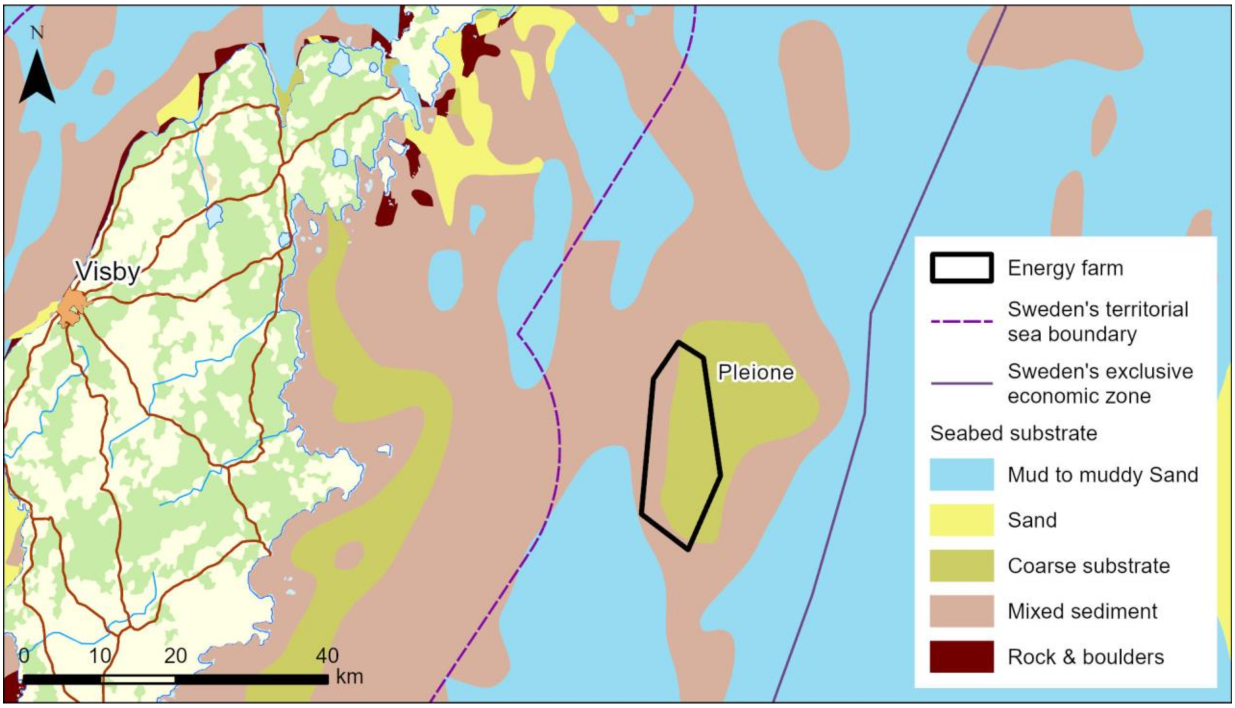

Figure 18 Bottom substrate in the farm area. Base map: © [National Land Survey] 2022 [Document EMODnet]

4.2 Hydrography and meteorology

The Pleione Energy Farm is planned for the Eastern Gotland Sea, where the salinity of the surface water is about 6–7 PSU (Practical Salinity Unit). The water temperature varies with the seasons, with higher temperatures during the summer and lower during the winter. The average surface temperature in summer is about 18–19 °C and in winter about 1–3 °C (Snoeijs-Leijonmalm & Andrén 2017).

The Baltic Sea is a brackish water inland sea that is largely characterised by a north-south salinity gradient. This is controlled by a supply of salt water through the Danish Straits and Öresund in the south-west and a supply of fresh water from watercourses in the extensive catchment area of the Baltic Sea. The gradient in salinity, with fresher waters in the north becoming more salty to the south, is reflected in the species distribution with more typical freshwater species in the north and more salt-water species in the south (Snoeijs-Leijonmalm & Andrén 2017).

Because salt water has a higher density than fresh water, the water is also saltier closer to the bottom than at the surface. There is a clear stratification in the Baltic Sea between fresh water at the surface and salt water at the bottom. At the bottom, oxygen is consumed in the water when organic matter breaks down. The salt layer makes it difficult for oxygen-rich surface water to sink to the bottom and oxygenate the water there, and because Öresund is so narrow and shallow, large inflows of oxygen-rich salt water from there are rare. Because of this, large areas are formed in the deeper areas of the Baltic Sea where the water is oxygen-poor or completely anaerobic – for example in the Eastern Gotland Basin where the farm is planned.

According to the New European Wind Atlas (New European Wind Altas, 2023), the annual average wind speed at 100 metres altitude in the farm area is about 9 m/s with a maximum wind speed of about 28 m/s. The wind direction is mainly south/south-west (SMHI, 2022a).

The energy farm is located in a part of the Baltic Sea that only becomes partially ice covered during the winters that SMHI classifies as severe ice winters, other years the area is ice-free. Ice formation is rare in the farm area, and according to SMHI's ice maps of maximum extent, no ice has occurred in the farm area for the past 10 years (SMHI, 2022b).

The water level in the Baltic Sea is mainly affected by air pressure and strong winds (Snoeijs-Leijonmalm & Andrén 2017). Due to weather dependence, the water level in special conditions can vary rapidly, with over one metre difference during the same day in some places (Snoeijs-Leijonmalm & Andrén 2017). The nearest sea level measuring station is in Visby harbour. The average water level at the station in 2012–2021 was +12.2 centimetres. The maximum value during the same time period was +84.30cm and the minimum value was -44.52cm (SMHI, 2022c).

The surface water currents in the Baltic Sea are the result of complex interactions between, among other things, the Coriolis effect, wind and the topography of the bottom. The Coriolis effect means that the speed at which the Earth rotates is greatest at the equator and decreases towards the poles because the circumference of the Earth is greater at the equator than at the poles. This has an effect on how the wind moves over the Earth's surface and therefore also on surface water currents. The currents are therefore irregular, but generally move in a counter-clockwise direction within the various major sub-areas of the Baltic Sea (Snoeijs-Leijonmalm & Andrén 2017). The surface water currents are generally weak, at around 5 m/s, but can reach between 50 and 100 m/s.

Deep water currents lead from the strait in the south-west to the north-east into the Baltic Sea. Deep water currents move more slowly than surface water currents and it takes about six months for salt water to travel from the strait to the Gotland deep (SYKE, 2020).

AquaBiota Water Research (now NIRAS) investigated oxygen conditions in the Pleione Energy Farm during June and September 2021. Good oxygen conditions were measured during both survey periods down to a depth of about 65 metres. After that, the oxygen sinks quickly and the waters is completely anaerobic already at a depth of 70–75 metres.

4.3 Natural environment

4.3.1 The Natura 2000 area

The area surrounding the energy farm has designated Natura 2000 areas both on land and at sea, see Figure 19. There are several small Natura 2000 areas both along the coast of Gotland and on nearby islands. The nearest onshore Natura 2000 area is located about 44 kilometres to the west of the energy farm.

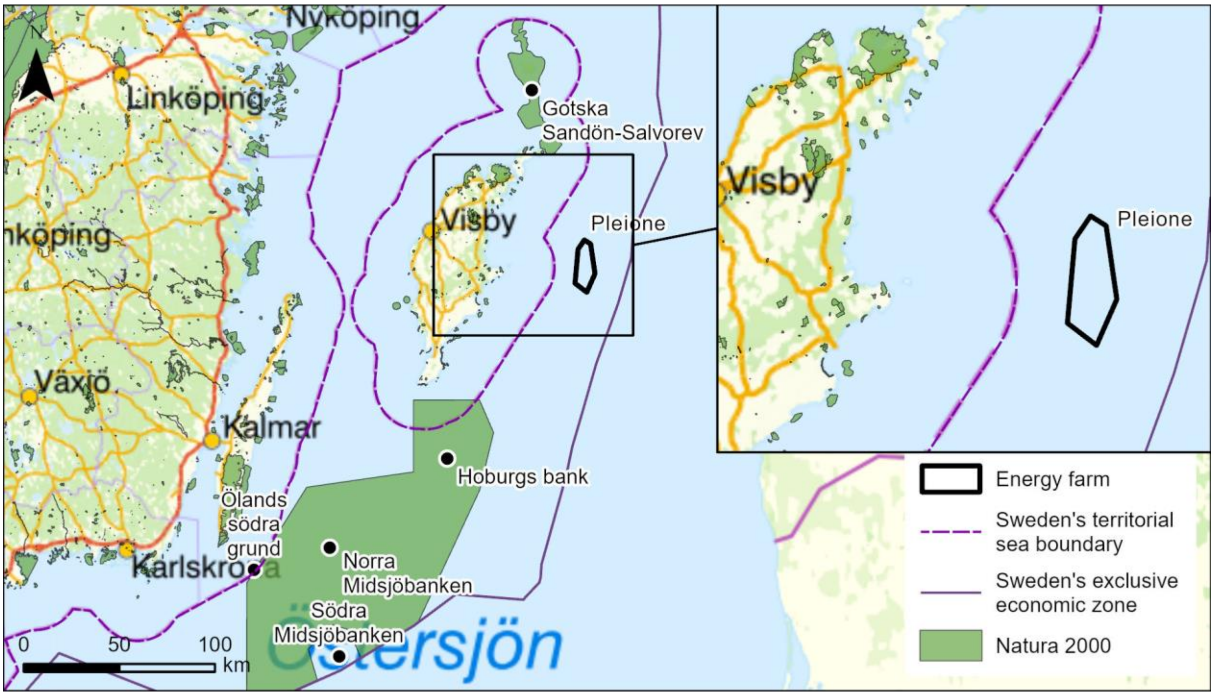

Figure 19. View of the location of the farm area in the Baltic Proper and bordering Natura 2000 areas. Base map: © [National Land Survey] 2021, [Document: Swedish Environmental Protection Agency]

The Natura 2000 areas of the Hoburgs bank and Midsjöbankarna (SE0330308) and Gotska Sandön-Salvorev (SE0340097) are close to Gotland, see Figure 19. The Natura 2000 area of the Hoburgs bank and Midsjöbankarna is located about 70 kilometres south-west of Pleione and has been designated as a protected area under both the EU species and Habitats Directive (a so-called SCI area) and the Birds Directive (a so-called SPA area) while Gotska Sandön-Salvorev is located about 47 kilometres north-west of the energy farm and has only been designated as an SCI area (Swedish Environmental Protection Agency, 2023).

The priority conservation values in the Natura 2000 area Hoburgs bank and Midsjöbankarna are the species of porpoises of the Baltic population, long-tailed duck and black guillemot, as well as the reef and sandbank nature types and the species and biological diversity that are typical of these habitats (Table 5). A conservation plan for the Hoburgs bank and Midsjöbankarna has been developed by the County Administrative Board of Kalmar County and the County Administrative Board of Gotland County. Porpoises are further described in section 4.3.7, and birds in section 4.3.5.

The priority conservation values in the Natura 2000 area of Gotska Sandön-Salvorev are the species grey seal and Boros schneideri and the nature types sandbanks, reefs, sandy Baltic beaches, dunes, white dunes, grey dunes, tree-lined dunes, dune wetlands, low-lying meadows and leafy meadows. Seals are further described in section 4.3.7.

Table 5. Nature types and species identified in accordance with the Species and Habitats Directive and the Birds Directive for the Hoburgs bank and the Midsjöbankarna and Gotska Sandön-Salvorev (County Administrative Board of Gotland County & County Administrative Board of Kalmar County, 2021).

Nature types	**Species**
The Hoburgs bank and Midsjöbankarna	
1170 – Reefs 1110 – Sandbanks	1351 - Porpoises A202 – Black guillemot A604 – Long-tailed duck
Gotska Sandön-Salvorev	
1110 – Sandbanks 1170 – Reefs 1640 – Sandy beaches at the Baltic Sea 2110 – Dunes 2120 – White dunes 2130 – Grey dunes 2180 – Tree-lined dunes 2190 – Dune wetlands 6510 – Low-lying meadows 6530 – Leafy meadows	1364 – Grey seal 1920 – Boros schneideri

4.3.2 Natura 2000 areas belonging to other countries

Natura 2000 areas belonging to the countries around the Baltic Sea (with the exception of the Russian Kaliningrad Oblast, in which there are no Natura 2000 areas) are located both offshore and along the coasts of the various countries, see Figure 20. The Natura 2000 areas of the Baltic Sea countries closest to the planned energy farm are Irbes saurums (Latvia), about 70 kilometres to the east, and Akmensrags (Lithuania), about 90 kilometres to the south-west. Irbes saurums is designated as a protected area under the EU Birds Directive, while Akmensrags is designated as a protected area under both the EU Species and Habitats Directive and the Birds Directive. Other Natura 2000 areas belonging to the Baltic Sea countries are located at a distance greater than 90 kilometres from the energy farm.

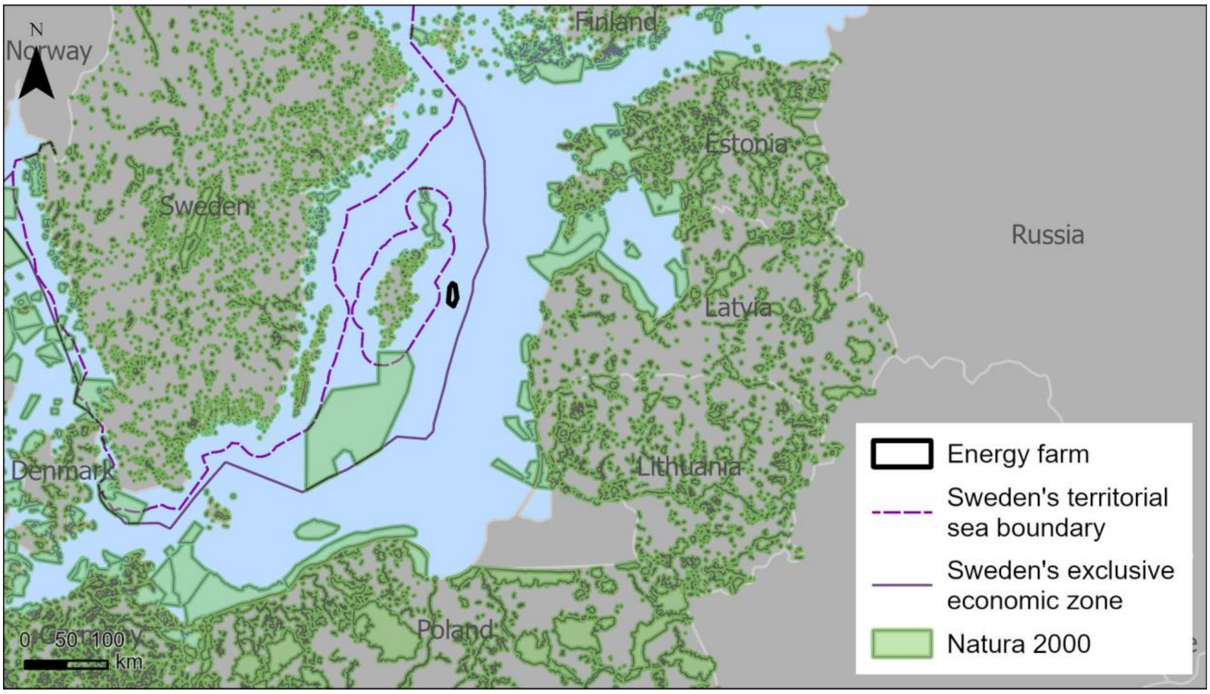

Figure 20. Map of all Natura 2000 areas in the central and southern Baltic Sea. Base map: © [Natural Earth] 2021, [documentation: European Environment Agency]

4.3.3 Bottom flora and bottom fauna

The composition of animal and plant communities living on and in the seabed depends on several factors such as water depth, salinity, oxygen content and bottom substrates (soft bottoms, mixed bottoms, hard bottoms, etc.). Hard and soft bottoms and seabed vegetation are all habitats that provide protection for numerous aquatic organisms. In the part of the Baltic Sea where Pleione is located, the species composition is mainly represented by a few bristle worms and polychaetes together with several mussels and crustaceans living above and in the sediments. Demersal animals and plants are directly or indirectly an important food source for fish, mammals and birds higher up the food chain.

During 2011–2012, Klint's bank and the waters east of Gotland were surveyed by the Oceana organisation, which later proposed the area as a potential marine nature reserve. It was considered to be, among other things, a potential refuge for some species during long periods of oxygen deprivation in surrounding deep areas (Oceana, 2014). In counts in the basic area, the County Administrative Board of Gotland observed four sessile species/organism groups, all of which were low-growing (Didrikas & Tano, 2018). The organisms with the greatest spread were blue mussel and hydrozoans, which were mainly noted concentrated around the shallowest areas of Klint's bank.

In the Swedish Agency for Marine and Water Management's marine plan, Klint's bank (area O233) is considered to have potentially significant natural value, linked to a climate change escape area for blue mussels (Swedish Agency for Marine and Water Management, Maritime Plan, 2023). Blue mussel banks are an important food source for both fish and seabirds and create hard surfaces that are important growth areas for other organisms (Norling & Kautsky 2008).

4.3.4 Fish

The Baltic Sea is home to a mix of salt and freshwater species, as it is a shallow sea with brackish water. Due to this, the fish fauna in the south-west of the Baltic Sea is dominated mainly by saltwater species, while the north-east consists of a combination of both salt and freshwater species.

The Pleione farm area has varying bottom types with oxygen-poor/anaerobic areas from about 70 metres depth. It is, therefore, probable that few or no benthic fish species are found at the deeper parts (>70 metres) of the farm. In those parts of the farm area where oxygen conditions are good, some species of flatfish commonly found in such habitats may occur. These species are scrub flounder and Baltic flounder (Jokinen et al. 2019), and turbot and plaice. Due to the low salinity of the eastern Baltic Sea, about 5–10 ‰, the individual density of these species is generally lower there than in, for example, the waters off Sweden's west coast. Pelagic species of fish such as sprat and herring are also common in the area (Swedish Agency for Marine and Water Management 2022c, HELCOM 2020).

The farm area mainly overlaps with potential spawning grounds and to a lesser extent with highly probable spawning grounds for sprat (Figure 21) (HELCOM 2020). The Gotland Deep to the east of Pleione has historically been an important spawning area for cod. In 2018, the spawning area was considered to be inactive as oxygen and salt conditions were too bad for the spawning to be successful (Viklund 2018). The species is expected to occur sporadically in the farm area, as is the case with European eel and salmon (Swedish Agency for Marine and Water Management 2022c).

A few fish species were noted at the Gotland County administrative board's survey of Klint's bank in 2018. The most common species was rock gunnel, which lived on the blue mussel banks at a depth of about 30 metres. Other fish species that were noted, but in very low individual densities, were shorthorn sculpin and cod (Didrikas & Tano 2018).

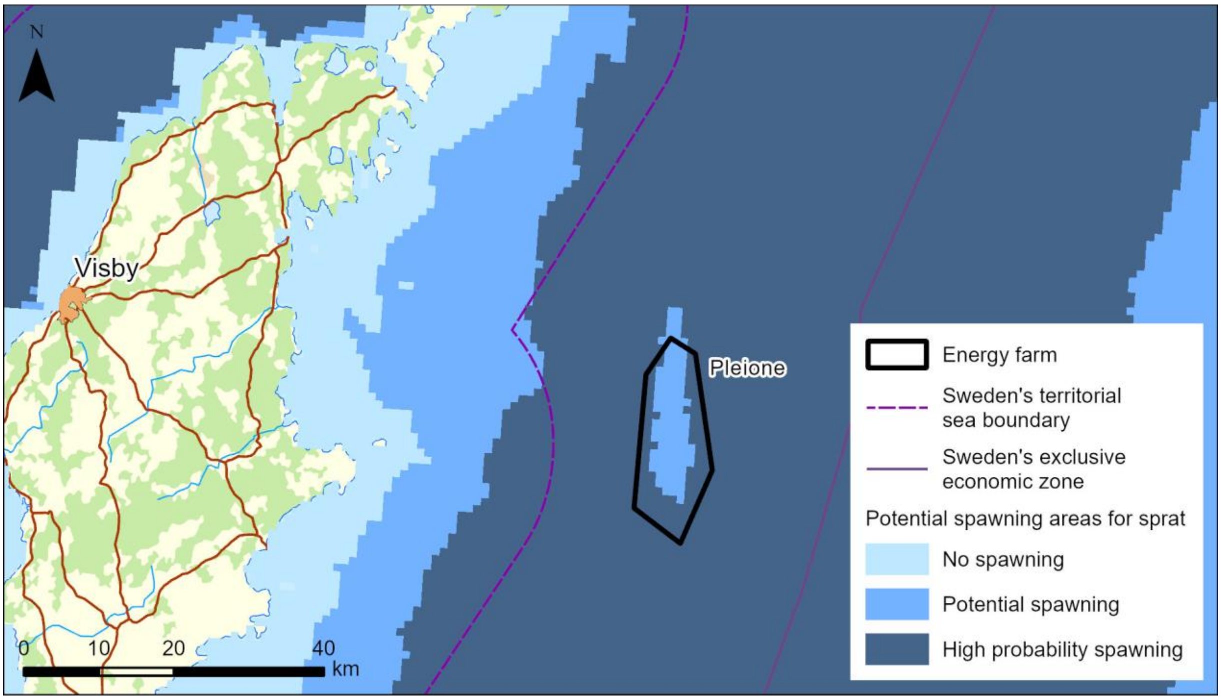

Figure 21. Map of the probability of sprat spawning grounds within Pleione. Base map: © [National Land Survey] 2021, [Document: HELCOM]

4.3.5 Birds

The sea areas in the central Baltic Sea are home to several species of seabirds as both overwintering, breeding and foraging area. Many seabirds pass through the central Baltic Sea in the spring and autumn migration periods. Birds can pass adjacent to the planned energy farm area in connection with these movements.

During spring migration, most species move in a north-eastern direction to the east of Gotland. During the autumn migration, most bird species move in a mainly south to south-west direction east and south-east of Gotland. Gotland forms a barrier for several species, which means that the birds either pass north of or south of the island. For other species, Gotland does not constitute a barrier and they can therefore pass directly over the island. Gotland is also an important resting place for many species. The movement patterns of birds during both spring and autumn migration east of Gotland differ between different species. A description of a general pattern is therefore a general description that cannot be applied to all species. The studies that have been carried out and will be carried out in 2023 are expected to provide more detailed information on migratory birds' movements during both spring and autumn migrations regarding the direction of flight, altitude and number of all species in or near the farm area. This applies to both day and night migratory species. Pleione tangents one of the “main routes” for spring and autumn migrating birds. The results of the spring and autumn migration surveys will be compiled and studied further in the autumn of 2023.

During winter, some species, such as a small proportion of the overwintering auks, move between different areas of the Baltic Sea and can therefore move through the Pleione area when they, for example, fly to the Baltic coast from Gotland or vice versa.

During the summer, large numbers of birds’ nest along the Gotland coast. Nesting seagulls and terns, including lesser black-backed gulls, Arctic terns and common terns, forage in the free water mass (they are so-called pelagic, which means that they do not depend on a specific depth) far out at sea. Nesting birds instead forage by diving for mussels and other bottom fauna in shallower waters. Many divers often dive down to seabeds at depths of 10–25 metres. Only less often do they dive down to depths of 25–35 metres because it is not profitable with regards to energy expenditure (Larsson, 2018). Further investigation will be carried out as to whether the Pleione farm area is used as a foraging area during the breeding period, and by which species and if so, to what extent it is used.

Several of the bird species that use the waters around Gotland have declining population trends and are listed on the Swedish Red List, Helcom's Red List and IUCN's Red List for species in Europe. This concerns, for example, eider, long-tailed ducks, black guillemots, red-throated loons, velvet scoters, and lesser black-backed gulls. Several species are also included in Annex 1 of the Birds Directive, such as smew, red-throated loons and black-throated loons.

It has been assumed that only a few species are likely to forage within the Pleione farm area during the summer. Nesting seagulls and terns, such as lesser black-backed gulls, Arctic terns and common terns, forage pelagically far out at sea, but due to the distance from Pleione to land, the density of these species is probably low within the project area. At Klint's bank, within the Pleione farm area, the water is shallower and blue mussels are found, although their density is relatively low, see section 4.3.3. However, the deepest areas of Klint’s bank are about 28 metres deep, so it is not expected that diving birds will forage there to any great extent, see above.

During the winter, many bird species overwinter off the eastern coast of Gotland. In a ship-based count at Klint's bank, no overwintering long-tailed ducks or auks were observed (Larsson 2018). Even during the winter, diving birds are not expected to use Klint's bank to any great extent, see section 6.3.4.

Auks, a family of birds that includes the species black guillemot, razorbill and common murre, and other species of birds, such as seagulls, which can also live on pelagic fish (e.g. sprat or other species living in the free water mass), may be present in the area. In flight counts it can be difficult to see what species of auk it is, which is why the collective term auk is used here. More counts are taking place in order to document the species' movement patterns to the east of Gotland.

4.3.6 Bats

Bats have been observed foraging at sea up to 20 kilometres from land (Ahlén et al. 2009) but can also be found out at sea in connection with seasonal migration (Hatch et al., 2013). Knowledge of where the bats' migration routes go is limited. However, there is a known migration route for the species of Nathusius' pipistrelle. It has a wide migration path, where the bats fly scattered. Therefore, during their migration bats flying along this route could pass through Pleione. It is not possible to rule out that there are more migration routes that pass through or near the farm area. Foraging and migration of bats over the sea takes place in relatively warm and windy conditions.

Of the 19 species that occur in Sweden, a total of 17 species have been reported to the Species Portal on eastern Gotland between 2000 and 2022. The observations have been made from land. The two species that are not reported, Bechstein's bat (*Myotis bechstenii*) and Alcathoe bat (*Myotis alcathoe*), are both rare species.

The Pleione farm area is so far from land that it is unlikely that the area would be used by bats for foraging. Bats may pass through the farm area during spring or autumn migration.

4.3.7 Marine mammals

Porpoises

There are two genetically distinct populations of porpoises in the Baltic Sea: The Danish Straits population and the Baltic Sea population. Porpoises from the Baltic Sea population can occur in low densities in and near the farm area. The Baltic Sea population has been estimated to consist of about 500 individuals (SAMBAH 2016) and is listed as being critically endangered (CR) according to the Swedish Red List (ArtDatabanken 2020). By-catches and environmental toxins in the 20th century are believed to be the cause of the strong reduction in the population. Today, by-catches are still a threat to the population, along with underwater noise and reduced access to prey. Porpoise is a designated species for the Natura 2000 area of the Hoburgs bank and Midsjöbankarna (County Administrative Board of Gotland & County Administrative Board of Kalmar 2021), which is located about 80 kilometres south-west of the farm area.

In a European collaborative project (SAMBAH 2016)), sound detectors (C-PODS), that recorded porpoises' high-frequency click sounds, were used to model the species' spread in the Baltic Sea during the years 2011–2013. The study identified key areas with higher densities of porpoises during different seasons Figure 22. The results show that porpoises gather around the offshore banks Hoburgs bank and Midsjöbankarna in the Baltic Proper during May-October, while they are more scattered during November-April (Carlén et al. 2018, Figure 22). The closest area identified as a protected area in the SAMBAH project includes the Hoburgs bank and Midsjöbankarna.

Pleione does not overlap with any area identified as important during the SAMBAH project.

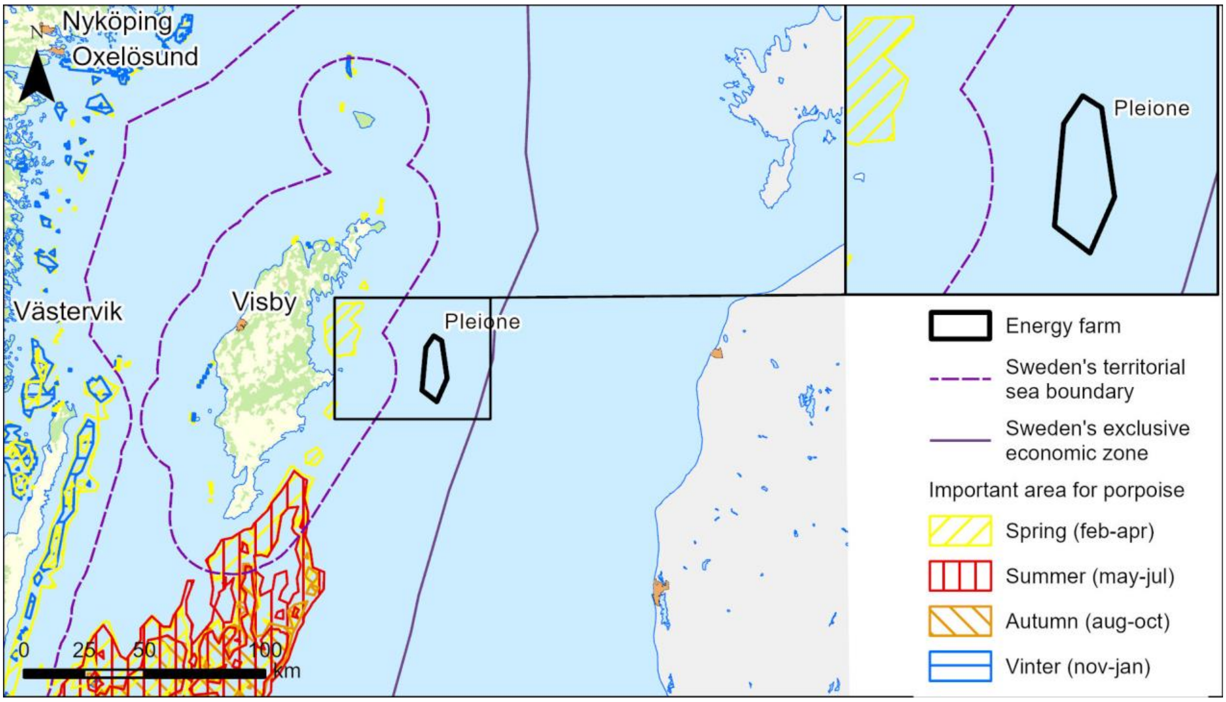

Figure 22. Important areas for porpoises in the immediate vicinity of the farm, per season. Base map: © [National Land Survey] 2021, [Document: Carlström & Carlén, 2016].

Seals

There are three species of seal in the Baltic Sea: Grey seal, common seal and ringed seal. Of the three species, it is mainly grey seals that can occur in the farm area, but occasionally solitary individuals of the other two species can also occur in the area. All three species are protected under Annexes 2 and 5 of the Habitats Directive. The grey seal is the most common seal species in the Baltic Sea. The population is assessed as viable (LC) according to the Swedish Red List (ArtDatabanken, 2020)) and has reached a good status according to HELCOM, (HELCOM, 2018b). Documented basking areas where grey seals change fur (so-called "haul-out sites"), are located both on Öland and Gotland. The closest areas to Pleione are located along the east coast of Gotland (HELCOM, 2018a). The grey seal is a designated species in the conservation plan for the Natura 2000 area of Gotska Sandön-Salvorev (see section 4.3.1). Common seals are divided into two sub-populations in the Baltic Sea, South Western Baltic and Southern Kalmarsund. Individuals from the Kalmarsund population are those that can possibly be present in the farm area. This subpopulation is listed as vulnerable (VU) according to the Swedish Red List (ArtDatabanken, 2020). The nearest known haul-out sites for common seals are located along the Öland coast (HELCOM, 2018a). The ringed seal Baltic Sea population consists of three subpopulations: The Gulf of Bothnia, the Gulf of Finland, the Gulf of Riga and the Estonian coastal waters. Single individuals from the latter subpopulation may potentially occur in and around both farm area during the ice-free period (HELCOM 2018a). The number of individuals in the subpopulation decreased between the years 1996 and 2003 and nothing is known about subsequent trends. A reduction in the ice-cover period due to climate change poses a major threat to the population of ringed seals. Ringed seals are classified as viable (LC) on the Swedish Red List but as vulnerable (VU) on HELCOM's Red List.

Pleione is located about 34 kilometres from the nearest grey seal location and about 48 kilometres from the Natura 2000 area of Gotska Sandön-Salvorev, where grey seal is a designated species, see Figure 23.

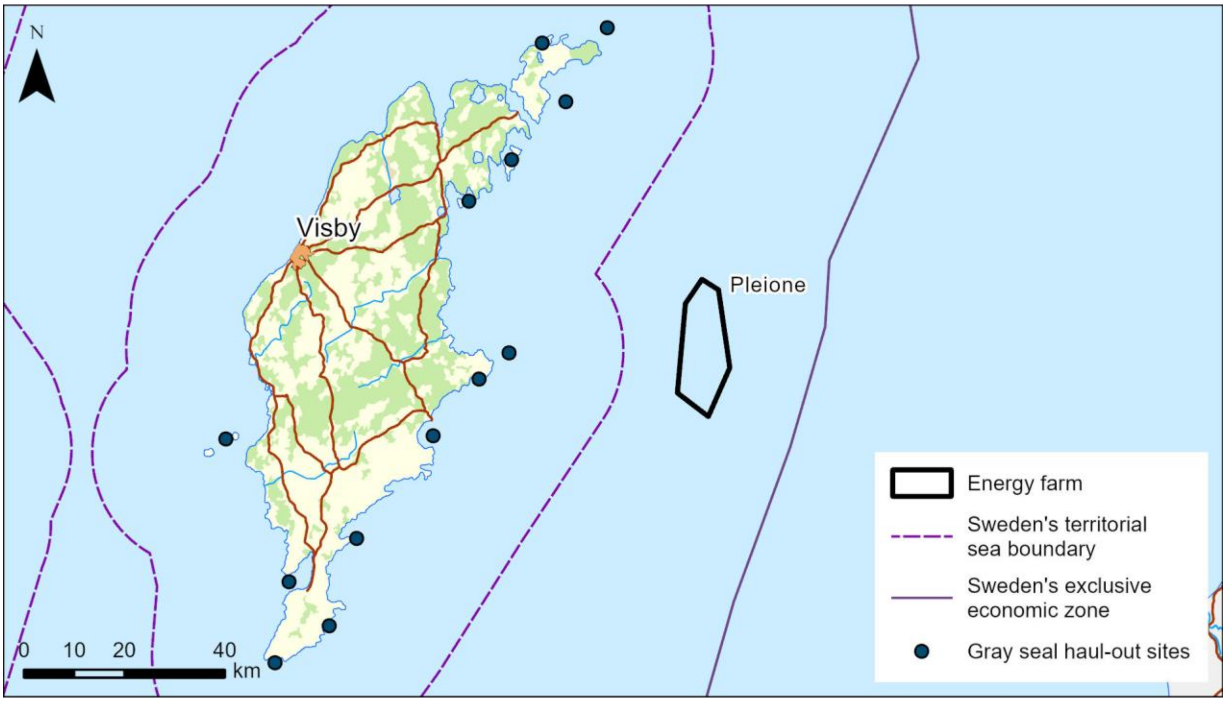

Figure 23. Map of grey seal haul-out sites. Base map: © [National Land Survey] 2021, [Document: HELCOM].

4.3.8 Green infrastructure for biodiversity and ecosystem services

The general biodiversity in the Baltic Sea has deteriorated in recent decades, along with some species of fish, birds and marine mammals, as well as habitats that are in an unsatisfactory state of health. Contributing factors to the current poor status of the Baltic Sea are poor oxygenation of bottom water as a result of, among other things, irregular supply of salt and oxygen-rich water from the North Sea, climate change and eutrophication. See the development over time for bottoms with oxygen-stressed and anaerobic in the Baltic Proper in Figure 24.

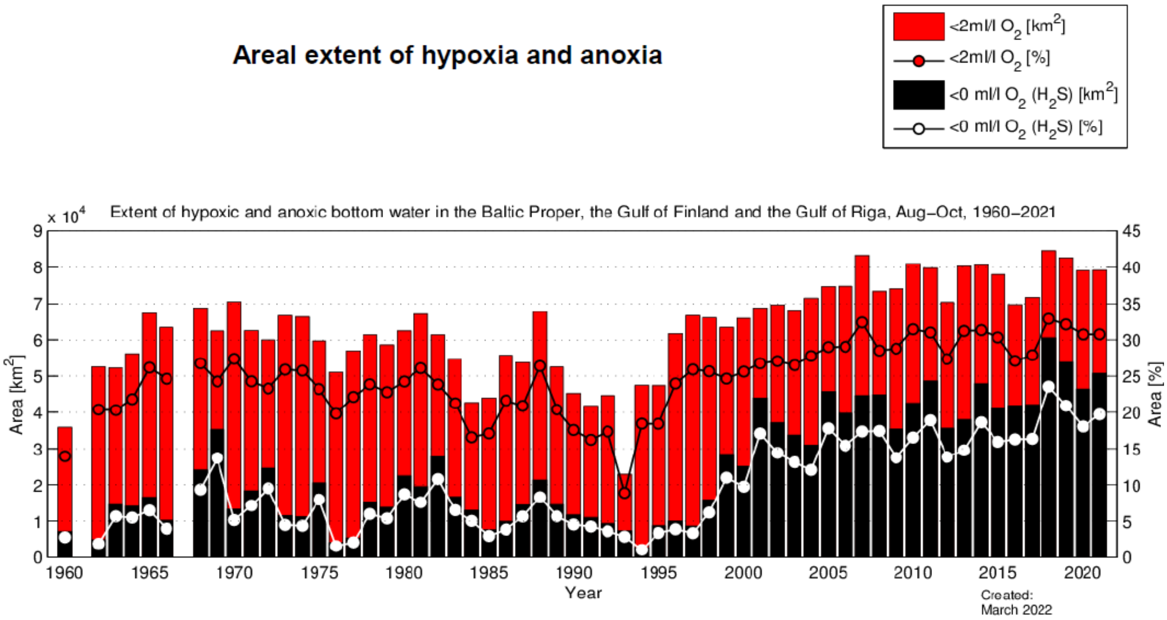

Figure 24. Development over time 1960–2020 regarding the area distribution of bottoms with oxygen-stressed (red, < 2 ml/l) and anaerobic (black, < 0 ml/l) conditions in the Baltic Proper (Hansson & Viktorsson, 2021).

A functioning green infrastructure is needed for the preservation of biodiversity and to benefit ecosystem services and their resilience to climate change. Green infrastructure is defined as ecologically functional networks of habitats, structures and natural areas, as well as the factors contributing to protecting biodiversity and the provision of important ecosystem services. Klint's bank, which is part of the planned Pleione farm area, has a high density of blue mussels and can contribute as a regulatory ecosystem service through water purification.

An ecosystem services are products or services that nature provides to man and that contribute to our well-being and quality of life. Examples of this include natural water regulation, climate regulation and natural resources. They can also be aesthetic values, resources for research and recreation.

4.4 Landscape scenery

Landscape scenery can be defined as a person's visual impression of the landscape. The visual impression is also affected by emotional aspects and past associations, which means that assessment can be highly subjective. Seascapes are characterised by flat horizontal surfaces with few colours and little variety, where the small structure that exists is usually only made up of small forested islands, islets and waves. The area in which the energy farm is planned is dominated by the free views of open sea. The extent to which the visual change in the seascape will be made depends on the nature, scale and use of the seascape. The extent of the impact depends on, for example, the size of the wind turbines, the distance to the wind turbines, the sensitivity of the seascape to a new element, lighting and even weather conditions.

4.5 Natural resources

4.5.1 Commercial fishing

Commercial fishing in the Baltic Sea is mainly focused on a few species. Cod, herring and sprat account for up to 95 % of total catches (ICES, 2023). Pelagic fishing (especially pelagic trawling), which is spread throughout the Baltic Sea, is mainly focused on herring and sprat (the Swedish Board of Agriculture and the Swedish Agency for Marine and Water Management, 2016). It is this fishery that contributes the largest catches in terms of tonnage in the region (ICES, 2021; Swedish Agency for Marine and Water Management, 2022b). The most important demersal trawling is bottom trawling aimed at cod and flatfish, especially flounder and plaice, which is concentrated in the southern and western Baltic. Other species of local and seasonal economic importance are salmon, dab, brill, turbot, pikeperch, pike, perch, whitefish, eels and sea trout. Coastal fishing (fixed gill nets/set gill nets, fyke nets and other types of stationary fishing gear) is sporadically spread across the area depending on the target species.

Pleione is located within ICES sea area 27.3.d.28.2. This is an international area in which landings from commercial fishing are recorded. In the maritime area, Sweden and Latvia accounted for most of the catch between 2006 and 2019, 41 and 33 % respectively. The catches consisted of 99 % sprat and herring. Danish and Lithuanian vessels also fish in the area, however, the extent of these countries' fishing in the farm area is limited. See Figure 25 and Figure 26.

Data from the Swedish Agency for Marine and Water Management on trawling by Swedish trawlers between 2013 and 2022 show that bottom and pelagic trawl fishing is most intensive close to the coast within the territorial waters outside the trawling border. Further out at sea, trawling activity is less intense and in the Pleione farm area there was hardly any trawling at all during those years.

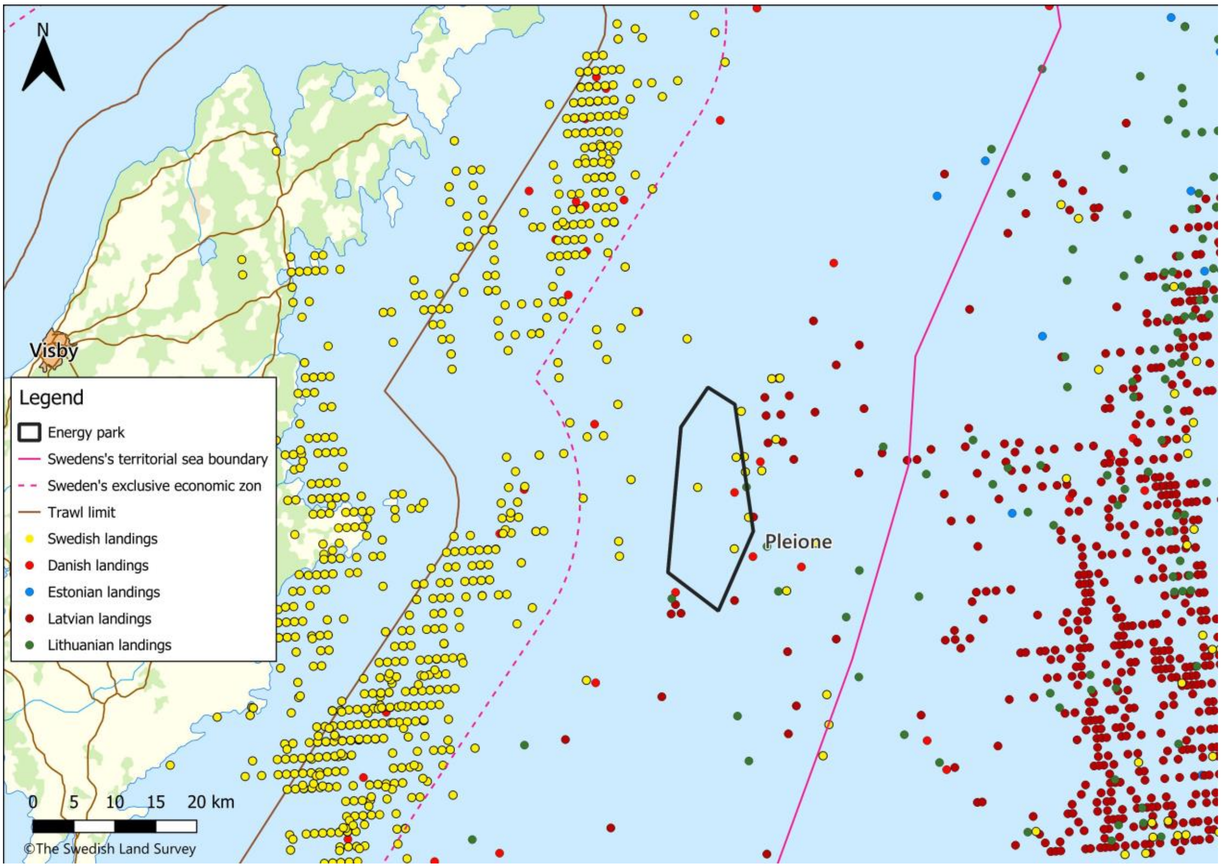

Figure 25 recorded catch points between years 2018-2021). Base map: © [National Land Survey] 2022 [documents the Swedish Agency for Marine and Water Management, and the respective authorities in Latvia, Lithuania, Estonia and Denmark]

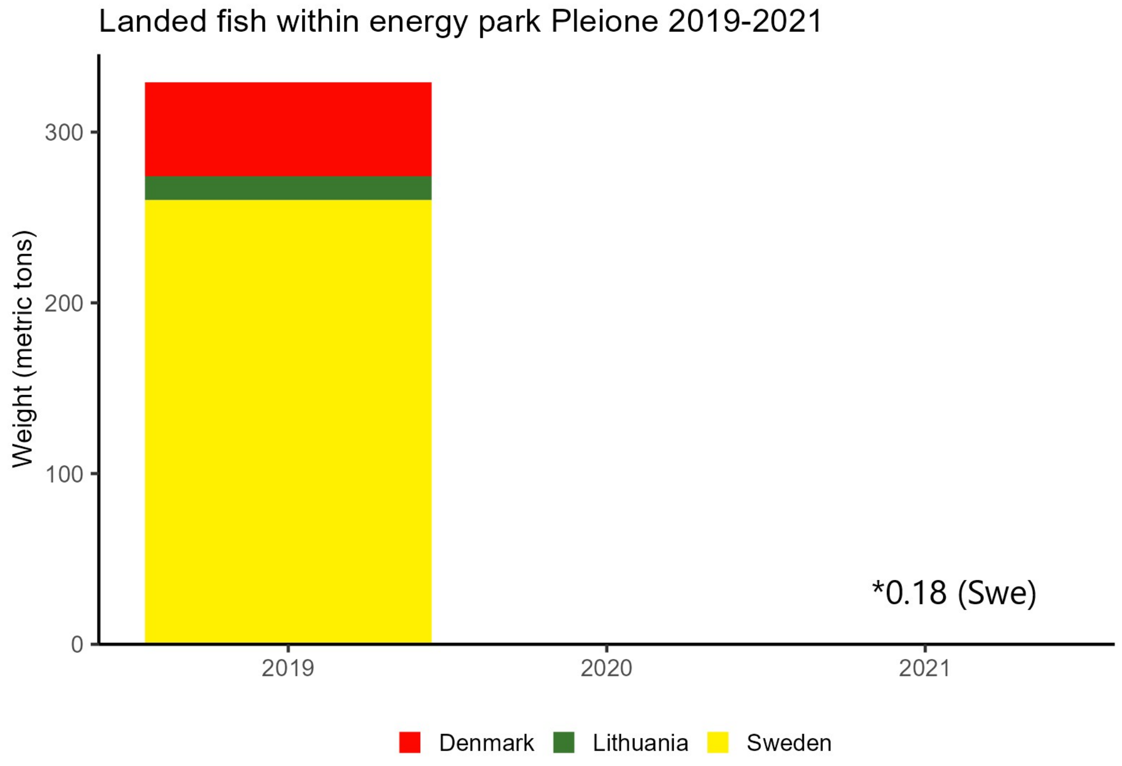

Figure 26. Diagram of landed catches within the Pleione Energy Farm. No fishing was reported in 2020 and in 2021 a catch of 180 kg was reported for Sweden. [Source: documentation from the Swedish Agency for Marine and Water Management, and the respective authorities in Latvia, Lithuania, Estonia and Denmark]

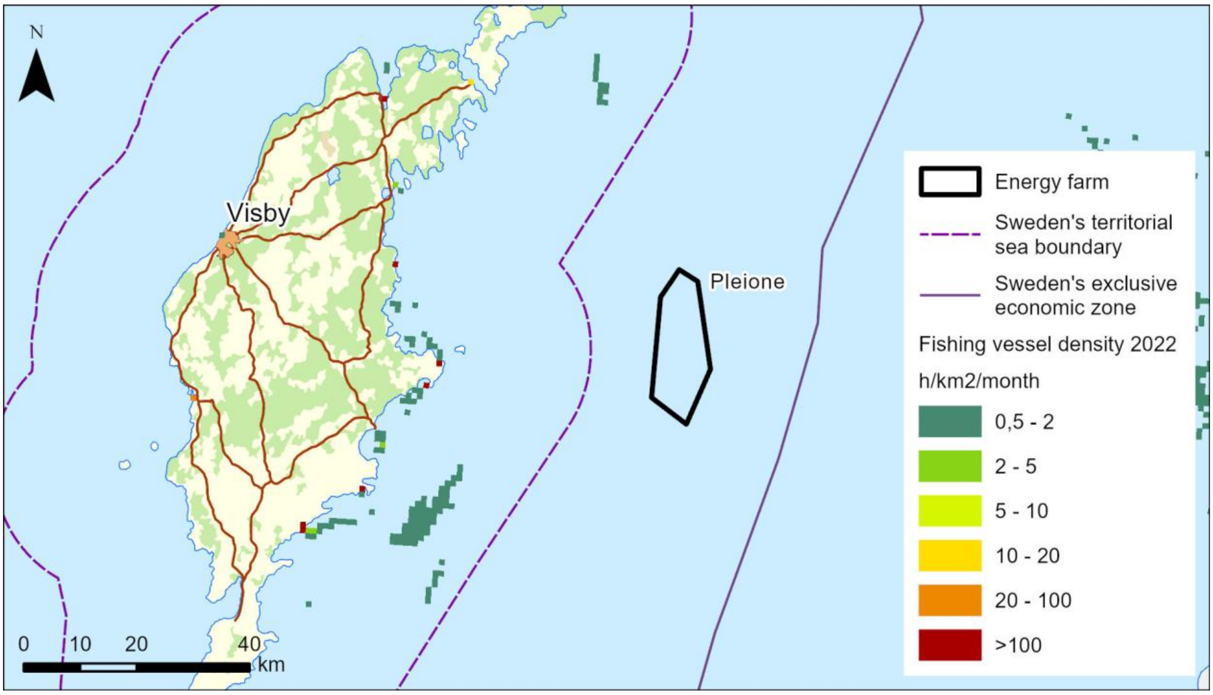

Figure 27. Density of fishing vessels (hours per 1 x 1 km square per month); Base map: © [National Land Survey] 2022 [Document EMODnet]

4.5.2 Mineral extraction

Mineral extraction from the seabed means that materials such as sand and gravel are removed from the seabed for primary use in the production of building materials. There is no designated area of interest for sand extraction in the area in maritime spatial plans (Swedish Agency for Marine and Water Management, 2022a).

4.6 Climate

The Baltic Sea environment is currently exposed to several stress factors, including eutrophication, environmental toxins and overfishing. Climate change has the potential to worsen the existing problems. Based on modelling, the sea temperature is expected to rise during this century (HELCOM, 2021), which would cause annual algal blooms to begin earlier in the spring. This leads to an increased load of organic material to the bottoms, which risks expanding oxygen-poor and anaerobic bottoms (Hjerne et al., 2019). This can lead to less successful recruitment of benthic fish and if the seabed becomes completely anaerobic only certain types of bacteria will be able to survive (Tallqvist et al., 2019; Hermans et al., 2019). The living conditions can change for several species in the Baltic Sea as light penetration, nutrient exchange in the water column and oxygen content may decrease and therefore very likely influence biogeochemical processes that in turn affect the entire ecosystem (Andersson et al., 2015).

Wind power is a central part of national measures to limit future climate change and to implement Sweden's climate target if the country is not to have any net greenhouse gas emissions by 2045. The energy farm thus contributes to limiting the impact of climate change, both globally and locally.

4.7 Infrastructure and planning conditions

4.7.1 Maritime activities

Two major shipping lanes are adjacent to Pleione's eastern and western borders. The movements of a large number of vessels (cargo, container, fishing, passenger, service and tanker vessels, etc.) can be tracked using Automatic Identification System (AIS) and AIS data from 2022 show that these types of vessel pass along the farm on their way in and out of the Baltic Sea (Figure 28). A significant proportion of the ship traffic outside the energy farm consists of large-scale sea transport.

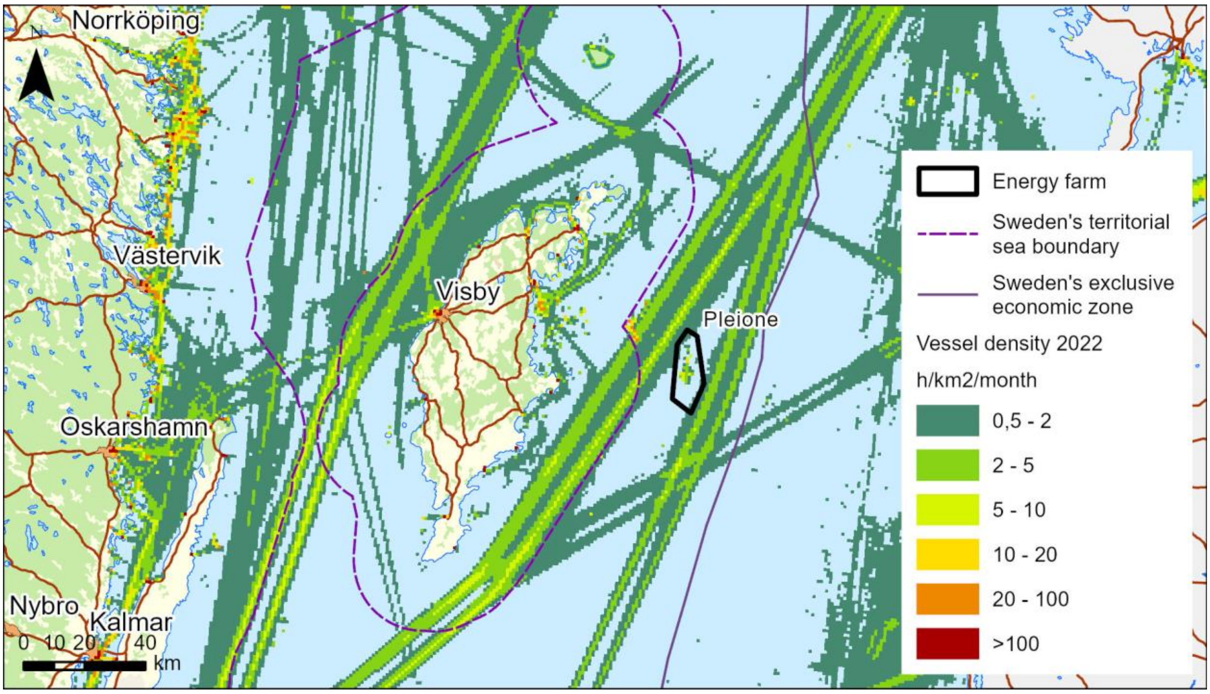

Figure 28. Map of all shipping in 2022 in hours per 1 x 1 kilometre square per month, as well as shipping routes in the immediate vicinity of the farm. Base map: © [National Land Survey] 2021 [Document EMODnet]

4.7.2 Aviation

The nearest airport to the farm is Visby Airport, located about 77 kilometres west of the farm area. The airport is used both by the military and as a civil aviation airport. A Minimum Sector Altitude (MSA) for an airport is a circle with a 55 km radius from the airport's landing aid devices. The area is divided into four sectors where the minimum permitted flight height is 300 metres above each sector's highest physical obstacle, which means that aircraft have a safety margin of 300 metres to the highest object in each sector (Swedish Transport Administration, 2014). The MSA area and project area do not overlap.

4.7.3 Military areas

The Swedish Armed Forces' naval exercise area of national interest is located about 21 km north of the farm area (Figure 29). On Gotland, near Hemse, there is the ASE (TM0091) weather radar which is a area of national interest for the military part of the Swedish national defence capability. The ASE weather radar is surrounded by a wind power prohibition area with a radius of 5 kilometres and by an impact area for weather radar with a radius of 50 kilometres. Visby Airport is also a area of national interest for the Swedish Armed Forces, i.e. a military airport that can be used in the event of heightened state of alert or war. Otherwise, the energy farm is not adjacent to any additional sea exercise areas, however, there is a sea exercise area belonging to Latvia about 44 km east of the energy farm (Figure 29).

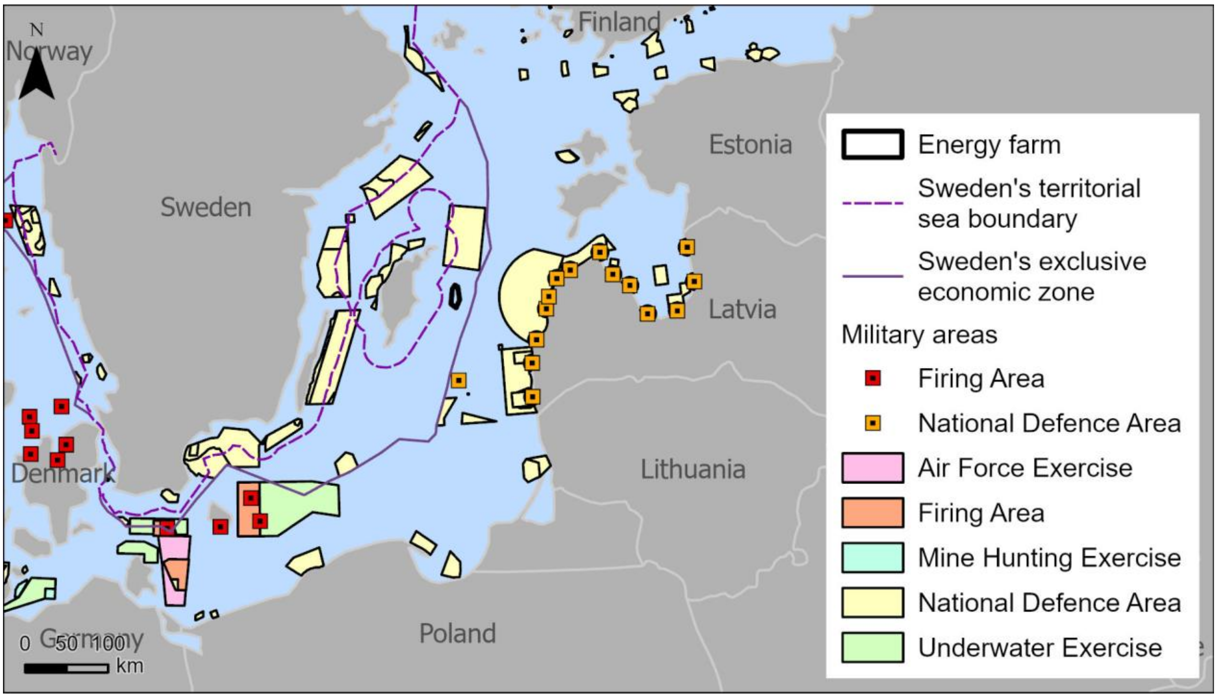

Figure 29. Other countries' military areas in the Baltic Sea. Base map: © [Natural Earth] 2021, [documentation: EMODnet]

4.7.4 Environmentally hazardous objects and dumping areas (mine risk areas)

After World War II, large quantities of chemical and conventional weapons were dumped into the Baltic Sea, to such an extent that the Baltic Sea today is probably the sea in the world that contains the highest concentration of mines, munitions and chemical weapons (Havet.nu, 2023). Many of these objects are still dangerous to come into contact with and a number of high-risk areas with a particularly high density of dumped munitions have been established (Swedish Armed Forces, undated). Dumped hazardous objects may also be present outside marked areas because they may have been dumped incorrectly or moved, for example having been towed by trawling vessels (Havet.nu, 2023). Within Pleione there is a known area with an increased risk of the occurrence of sunken mines (Swedish Maritime Administration, 2023) (Figure 30).

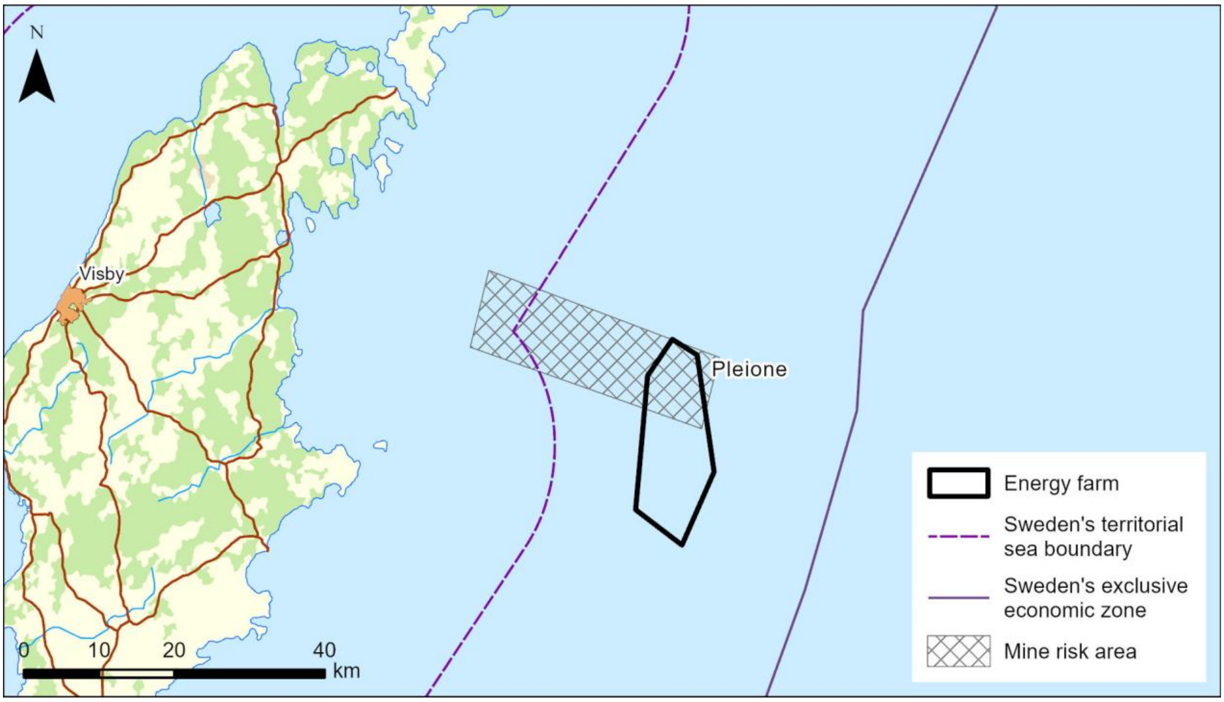

Figure 30. Mine risk areas. Base map: © [National Land Survey] 2021, [Document: Swedish Maritime Administration, Swedish Marine and Water Management Agency]

4.7.5 Other activities

No existing offshore wind farms are located near the energy farm, but the nearest existing wind farms are onshore, on Gotland's north-east coast. These are Smöjen wind farm 1 and Rute Furillen Slitevind XI & XII. The Smöjen wind farm 1 consists of 11 wind turbines with a total output of 11.6 MW (Slitevind, 2022). The farm has been in operation since 1995. Rute Furillen Slitevind XI & XII consists of two wind turbines (Vindbrukollen, 2022). The nearest offshore wind farm is Bockstigen 1, Sweden's first offshore wind farm, located west of Gotland.

OX2 is planning a wind farm about 20 km west of Pleione, called Ran. The project is currently in the consultation phase. The company Deep Wind Offshore is planning a wind farm 32 kilometres north of Gotska Sandön, i.e. north-west of Pleione's northern border. The proposed area of the wind farm is 1098 km^2. The consultation phase within the project has been completed and an EIA has been prepared for the permit application (Deep Wind Offshore, 2022). The company Njordr Offshore Wind is also planning a wind farm about 31 kilometres north-east of Gotska Sandön. The farm area is 678 km) in size and the project is in the preparation phase for the permit application, with the aim of submitting the application in 2024 (Njordr Offshore Wind, 2022). The Irish company Simply Blue Group is planning two wind farms near the farm area: Herkules, located south-east of Pleione, and Skidbladner, located north-west of Pleione. Both projects are in an early planning stage (Simply Blue Group, 2023). OX2 is planning a wind farm, called Aurora just over 90 kilometres south-west of Pleione. A Natura 2000 application was submitted in March 2022 and the SEZ authorisation application was submitted in June 2022. At least two wind farms are planned in Latvian waters and the distance to the closest farm is about 63 kilometres from Pleione. The status and timetable of the projects are unclear (The Windpower, 2023).

Figure 31 below shows the nearest planned farm areas.

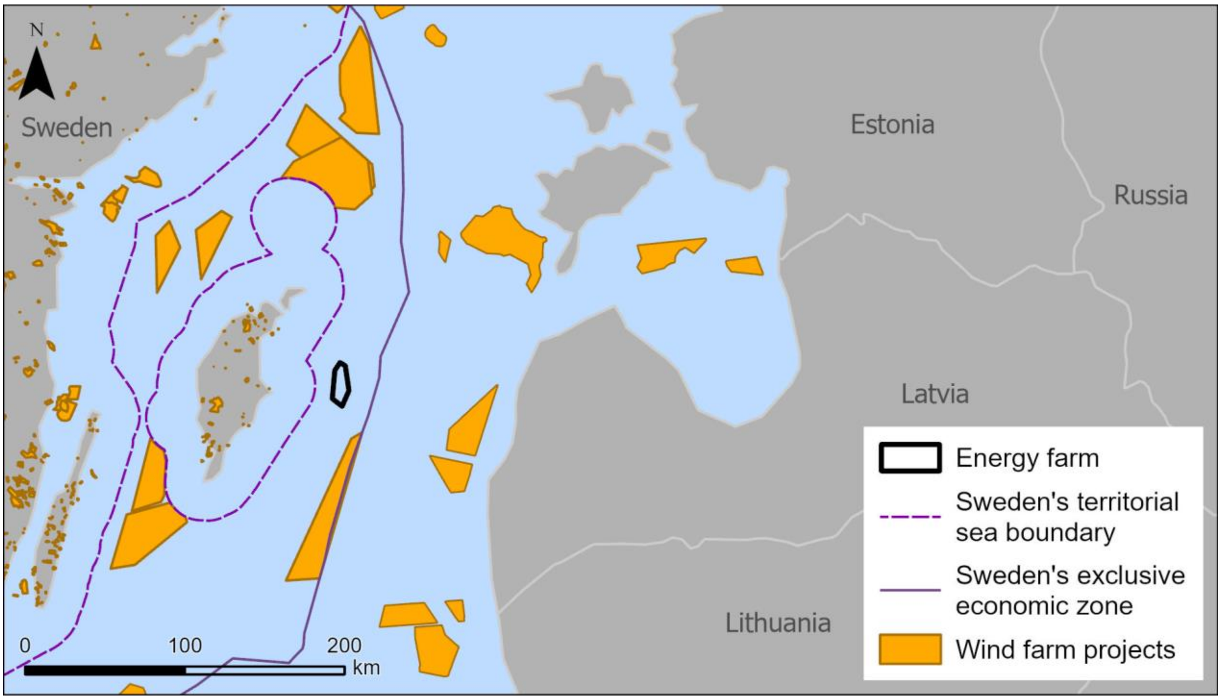

Figure 31. The farm area for Pleione and nearby planned activities. Base map: © [Natural Earth] 2021, [documentation: EMODnet].

The Nord Stream 1 and 2 natural gas pipelines are adjacent to the Pleione farm area, see Figure 32. The Nord Stream pipelines run from Vyborg in Russia to Lubmin in Germany. The pipeline system construction work was completed in 2012 (Nord Stream, undated).

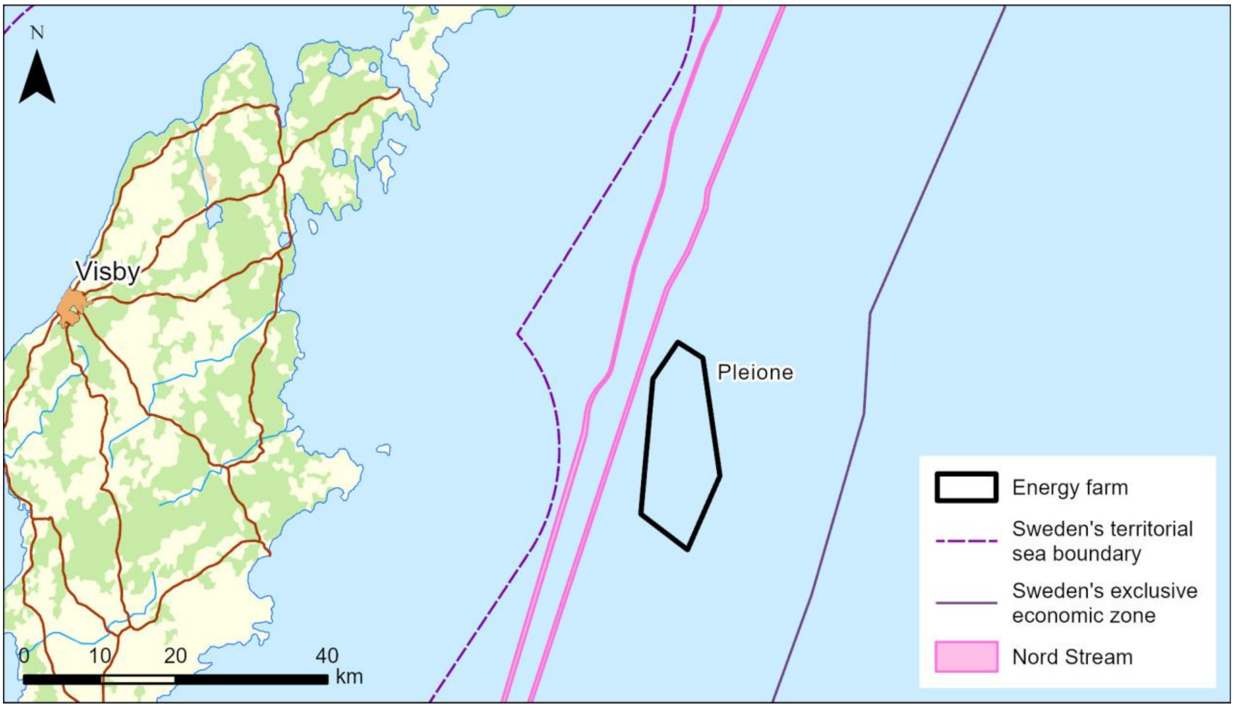

Figure 32. The area for the energy farm and the Nord Stream 1 and 2 natural gas pipelines. Base map: © [National Land Survey] 2021

5. Risk and safety

5.1 General risk and safety associated with wind and energy farms

Construction of an offshore energy farm places high demands on safety, which means that this will be a priority issue during all phases of the project. The risks from a large-scale wind or energy farm can be clearly divided into risks to human health, risks to the environment and risks to individual or public property.

Risks to human health must be considered in relation to, for example, work carried out at height, work involving heavy lifting or work involving the handling of electrical equipment. Risks to the environment may consist of discharges of oil or other chemical products, the spread of bottom sediments stirred up during construction work, the occurrence of disturbing noises, for example in connection with construction and the establishment of foundations, or risks related to the production and management of hydrogen. Risks of damage to public or private property may arise, for example, during vessel movements at the farm area or when handling heavy components. Dumped ammunition or other weapons pose a particular risk, which means that the possible presence of these objects at the farm area must first be identified by geophysical surveys.

The general management of risks can be described in the form of a so-called action hierarchy. In the first instance, the risk must be eliminated by completely avoiding the hazardous work moment or by replacing it with a less risky one. The next step is to use technical or administrative measures to reduce the likelihood and impact of a hazardous event and to be prepared for action if the hazard occurs.

Risk analyses will be carried out continuously throughout all phases of the project. An identified risk must always be assessed and evaluated and, where appropriate, managed through risk mitigation measures. Procurement processes must ensure that suppliers comply with the project's high requirements for safety and risk minimisation. Risks will be described in more detail in the forthcoming environmental impact assessment.

5.2 Risk and safety associated with large-scale chemical processing

Large amounts of hydrogen and oxygen will be produced and processed in the planned Pleione farm area, which will result in the risk of accidents. The amount of oxygen and hydrogen processed in these operations means that Pleione is subject to the higher level of requirements under the Seveso legislation. Design of the energy farm will focus on safety aspects and special attention will be paid to prevent accidents when deciding on the design for the wind farm. A survey of risks and an assessment of necessary risk mitigation measures to minimise risks to the environment and health is ongoing.

As the operations are subject to the higher level of requirements, the permit application will also include a safety report that describes safety principles and the operations' risk management, as well as an internal plan for rescue operations.

5.2.1 Identified risks

From a Seveso perspective, the risks associated with handling of hydrogen, oxygen and diesel are most relevant. Depending on the final design for gas production, the exact risk spectrum varies. Pipelines and buffer tanks within the energy farm could be exposed to, for example, shipping traffic, extreme weather and earthquakes. In addition, if hydrogen buffer tanks are installed on specific platforms within the energy farm, the risks may increase locally, considering the volumes of hydrogen located in a single location. Oxygen pipelines for potential oxygenation of the seabed at places other than within the defined farm area will also be covered by the application and thus also analysed within the framework of the relevant permit.

A rough risk analysis has been carried out to identify dimensioning risk scenarios. Due to large distances for potential impact, the design risks for humans are: jet flames, gas cloud fires, and detonation due to ignition of a hydrogen leak. A jet flame usually affects its direct proximity, within a couple of hundred metres and the effect is mainly in the direction of the jet flame, while the consequences of gas cloud fires and explosions are in all directions. Extensive oxygen leakage mainly involves the risk of domino effects through elevated oxygen concentrations in and around machinery and process equipment, which can intensify an already ongoing fire. Discharges of diesel and oils are dimensioning environmental accident scenarios and are judged to be possible as a result of collisions, allisions (an impact between a ship and a stationary object), fire, or other external accidents or antagonistic actions.

In addition to the dimensioning risk scenarios, fire and physical impact on ships and wind turbines with persons present have also been identified as relevant scenarios. As diesel, transformer oil, and turbine oil, for example, will be handled, pool fires have also been identified as a risk. However, that risk has only local consequences for life and health, and will be investigated as a domino effect of, for example, allisions, fire, or hydrogen accidents.

5.2.2 Risk mitigation measures

The preliminary and overall risk mitigation measures proposed include, among other things, safety distances to nearby shipping routes and within the facility, drains for containers containing environmentally hazardous substances, fire protection measures and good operating and maintenance procedures. There are no other Seveso facilities in the surrounding area that could affect, or be affected by, the energy farm. However, there are the Nordstream 1 and 2 natural gas pipelines as well as the risk of possible dumped munitions and other weapons in the permit area. This will be investigated within the framework of future applications regarding domino effects in the event of an accident. Risks related to hazardous goods transport will also be investigated in the same way.

The energy farm must be planned in such a way that the above-mentioned risks to passing cargo and/or passenger vessels are low by introducing safety distances and/or other risk mitigation measures. It will be ensured that operational personnel who will work in the energy farm have good knowledge of the risks and receive the necessary training on, among other things, how to act in the event of an accident. As the Pleione Energy Farm is located about 40 kilometres from densely populated areas, the risk to third parties in the form of people on land is considered negligible.

An internal emergency plan will be developed in consultation with the relevant authorities as part of the safety report. Close cooperation with the relevant authorities is required, in which Pleione Energipark AB will support the measures necessary to supplement the state emergency services' ability to act in the event of an accident. Within the framework of the safety report, the risk assessment will also comprehensively report the requirements for the design of the installation pursuant to the Act on flammable and explosive goods (2010:1011). The report will also report accident risks with an impact on the environment and health, as well as planned safety measures to prevent and limit serious chemical accidents.

6. Preliminary environmental impact

The impact of the energy farm can occur during three different phases: The construction phase, the operational phase and the decommissioning phase.

This section deals with the various potential environmental effects of the energy farm that must therefore be considered in the forthcoming process. The potential transboundary impacts are presented in section 7. Only the phases that are deemed to have an impact are highlighted in the description for each environmental aspect below. The forthcoming environmental impact assessment will describe the environmental impacts and their consequences and assessed them in more detail. The assessments of the environmental impacts and its consequences will be based on a worst case- scenario for each recipient group. For example, the effects on marine mammals in terms of underwater noise will be assessed based on the foundation type that generates the highest sound levels in connection with its construction. Similarly, the environmental impact on bottom flora and fauna regarding sediment spreading will be estimated on the basis of the use of the foundation type causing the highest concentrations of suspended material.

6.1 Geology and bottom conditions

The main environmental impact on geology and seabed conditions that arise from the establishment of an energy farm is the loss of existing substrates and the replacement with hard substrates and hard structures for the construction of foundations, cables and pipelines, in addition to erosion protection. The extent of this impact depends mainly on the choice of foundation. Monopile and jacket foundations occupy different sizes of the seabed area and require anchoring between 50–95 metres down in the seabed. This, therefore, also requires erosion protection, which leads to an impact on the geology in the vertical direction. Floating foundations occupy less seabed space, as the foundations only need to be anchored to the seabed. The duration of the change in the seabed surface depends partly on the useful life of the farm and partly on whether the foundations are removed or left in place in connection with decommissioning.

All in all, the total impact on geology and seabed conditions during the construction, operational and decommissioning phases is expected to be negligible, as the size of the total seabed surface area by the foundations is very small.

6.2 Hydrography

Changes in the hydrography can be divided into currents, waves and vertical mixing of surface and bottom water. Hydrological changes due to vertical mixing are mainly due to current speed, the strength of the pycnocline and whether the foundation of the wind turbine is deeper than the pycnocline (Hammar et al., 2008a).

Several hydrographical studies have been carried out in connection with the construction of marine structures in Sweden, for example for the Lillgrund wind farm and for the Öresund Bridge (Øresundskonsortiet, 2000; Møller and Edelvang, 2001; Karlsson et al. 2006). In these studies (and/or modelling), only marginal changes can be measured in comparison with previous background values. Simulation of the impact of the Lillgrund wind farm showed that wave energy and current speed decreased by about 5 % within the farm, which is not considered to affect the conditions outside the farm area (Edelvang et al., 2001). Wind turbines are not expected to impact on hydrographic changes except in smaller waters such as narrow water passages. The changes in wave and current patterns observed around wind turbines have been marginal (Hammar et al., 2008a). Floating foundations are assessed to have a lesser impact. As platform foundations are of the same nature as those for the wind turbines, the impact is assessed to be the same as for the turbine foundations. However, when seawater is pumped up to the electrolyser and oxygen and hot brine is then returned to the sea during hydrogen production, this may affect the hydrography locally. Potential impacts will be investigated and described in more detail in the environmental impact assessment.

As the Pleione Energy Farm is not located in a narrow water passage but in the open sea far from the coast and with a significant bottom depth, the impact on hydrography during the construction, operation and decommissioning phases is expected to be limited.

6.3 Natural environment

6.3.1 The Natura 2000 area

The expected impact of the activities on the nearby Natura 2000 areas (see Figure 19) will be examined in greater detail for future environmental impact assessments.

The Natura 2000 areas contain a number of designated species and habitats. The preliminary assessment is that the construction, operation and decommissioning of Pleione is not expected to present a risk of any impact on foraging birds that are included in nearby Natura 2000 areas. Provisionally, no impact on marine mammals, including the designated species and habitats belonging to Natura 2000 areas at sea is expected to occur as a result of the planned farm. The main reasons for this are explained below in brief.

Marine mammals

The greatest impact on marine mammals is expected during the construction phase. Porpoises are a species of note for the Natura 2000 area Hoburgs bank and Midsjöbankarna. The farm area is so far away from the Natura 2000 area that noise from the activities, with the mitigation measures applied, is not expected to have any impact in the area. Although occasional porpoises may be in or near the farm area sporadically, the temporary displacement of porpoises from these areas is not considered to have a significant impact on porpoises or the conservation values of the Natura 2000 area. The grey seal is a designated species in Gotska Sandön-Salvorev. This Natura 2000 area is also so far away from the farm area that noise from the activities, with the mitigation measures applied, is not expected to have any impact on the grey seals at the area. The farm area is also not considered to be of particular importance as a foraging area for grey seals and a temporary displacement effect from the farm area is not expected to have a significant impact on grey seals or the conservation values of the Natura 2000 area.

Birds

During the construction and decommissioning phase, birds will be mainly affected by increased boat traffic, which can lead to some barrier or displacement effects. The greatest impact from an energy farm normally occurs during the farm’s operational phase, see more in section 6.3.4.

The surveys carried out indicate that black guillemot and long-tailed duck, which are designated species in the conservation plan for the SPA area Hoburgs bank and Midsjöbankarna, are only occasionally present at Klint's bank. Larsson’s (2018) inventories did not note long-tailed duck or black guillemot at Klint’s bank. This is probably since diving for mussels, etc. is not considered to be a profitable expenditure of energy for the birds because the food source is at too great a depth. In view of the relatively large water depth and the lack of observed birds during the winter, the Pleione farm area is not considered an important and relevant foraging area for these species. It is not expected that the opportunities for black guillemot and long-tailed ducks to fly to and from the Natura 2000 area of Hoburgs bank and Midsjöbankarna as an overwintering area are significantly affected by the operations due to Pleione's location in relation to the SPA area.

The nesting bird species identified in the conservation plans for the SPA areas along the eastern coast of Gotland are located almost exclusively in areas located on land or in more coastal water areas, and at a great distance from the farm area and are not, therefore, expected to be affected.

Nature types

Areas designated under the Species and Habitats Directive (SCI areas) aim to ensure biodiversity through the conservation of naturally occurring habitats and species occurring there. All designated nature types within Natura 2000 areas on the Gotland mainland occur at too great a distance from Pleione to risk any impact from the operations.

The current marine nature types identified for Gotland Sandön-Salvorev and Hoburgs bank and Midsjöbankarna are sandbanks and reefs. In addition to these, a number of nature types on land have been singled out for Gotska Sandön-Salvorev. All of these habitats are expected to be too far away from Pleione for any impact to occur.

6.3.2 Bottom flora and bottom fauna

The effects on bottom flora and fauna are mainly due to the physical disturbances to the seabed caused by the installation of foundations, erosion control, inter-array cables and internal pipelines. On the one hand, animals that live on a surface can be directly damaged during the work, but the construction of wind turbine foundations also gives rise to temporary spread of harmful suspended particles. Some organisms may be covered by sediments, which may be distressing for some species. Installation of the inter-array and the internal pipeline network may also result in local distribution of sediment, depending on the choice of installation method.

In those parts of the farm area where the bottom substrate is made up of clay, mud and sand seabed, the bottom fauna is dominated by animals that live buried in the sediment, so-called infauna. Usually, such species are not adversely affected by an increased amount of suspended sediment and increased sedimentation, as they are adapted to living in such environments. The organisms also have the ability to repopulate a disturbed area quickly after a disturbance has stopped. Parts of the deep bottoms in the farm area also consist of completely anaerobic seabed, which means that there will be a more or less non-existent presence of demersal organisms in these parts. However, the areas where the seabed is home to blue mussel banks may be affected by increased amount of sedimentation. The impact on bottom flora and fauna is therefore considered to be greatest in those parts of the farm area that have shallower depths and coarser bottom substrates, where most marine nature values in the form of bottom flora and fauna occur.

Sediment spread models will be developed to estimate the distribution pattern in connection with the construction of Pleione. Sediment spread models will serve as a basis for deeper analysis of the effects of sedimentation on bottom flora and fauna in future environmental impact assessments.

During the operational phase, the primary impact on bottom living organisms will be disturbance and loss of habitats where excavation of the seabed has taken place, foundations and erosion protection have been installed and have replaced existing habitats. The amount of habitat loss depends on the design of the farm, i.e. the size and number of wind turbines and foundations. The loss of soft-seabed habitat is expected to be very small in relation to the remaining amount of soft-seabed habitat. Blue mussel banks may be affected if turbine foundations are built in areas where such banks are located. However, new hard structures are added during establishment of the foundations that can constitute new potential habitats for establishment of the blue mussels. The activity can therefore have both an intrusive and beneficial effect on blue mussels.

The area at Klint's bank has been designated as Swedish marine plan area Ö233 for general use with regard to high natural values, including as a climate refuge for blue mussel. Because the wind turbine foundations consist of hard structures that can be used by blue mussels to establish themselves on, the function of the area as a climate refuge for blue mussels is not adversely affected by the activity.

Installation of the foundations in the farm area, as well as anchors for floating foundations, will lead to the introduction of new substrate in parts of the area in which species that thrive on hard bottoms can establish themselves. These hard bottom surfaces will be unique in the deep soft-bottom areas and contribute to a so-called reef effect, as hard-bottom species can establish themselves locally in connection with the wind turbines and can contribute to increasing biodiversity (Wilhelmsson & Langhamer, 2014; Lu et al., 2020).

The impact of hydrogen production in the Pleione Energy Farm in the form of discharge of cooling water and brine also occurs during the operational phase. Because the cooling water has the same salinity as the surrounding water, but a higher temperature, it will rise to the surface and thus not affect the bottom environment. The brine plume, on the other hand, can reach the seabed at the most shallow parts around Klint's bank, but with a salinity similar to the surrounding water. In those areas where the depth exceeds the halocline (salinity gradient layer), the plume will not reach all the way down. Hydrogen production also creates oxygen. Pleione Energipark AB will potentially use this oxygen to oxygenate the bottom water, which could enable demersal animals to be established in places that are currently oxygen-poor or anaerobic. Demersal animals are an important source of food for fish, which in their turn provide food for birds, other fish and marine mammals. Potential impacts and potential mitigation measures to minimise the potential impact of hydrogen production will be analysed in more detail in the forthcoming environmental impact assessment.

During the decommissioning of foundations and cables, some sediment spreading may occur, but not to the same extent as during installation. Any positive effects from oxygenation and reef effect will disappear if the operation is dismantled.

6.3.3 Fish

Demersal fish species, species that live at the bottom of the sea, are not expected to be present to any great extent in the deeper parts of the farm area, due to poor oxygen conditions at the bottom. However, these fish species can be present to a greater extent around the shallower areas where oxygen conditions at the bottom are better. The species that may be concerned are shorthorn sculpin, long spined oxhead, fourhorn sculpin, flounder, Baltic flounder, turbot, plaice and cod. Pelagic species such as sprat and Baltic herring are expected to be more common in the farm area.

During the construction phase, increased sediment spread from drilling, dredging and piling may have an impact on fish. Fish roe and fry can be affected as suspended particles can, under certain conditions, become trapped in gills, cover roe and result in poorer conditions for survival. Particles are most likely to get stuck in juvenile fish gills as their swimming skills are poorer and they cannot avoid affected areas, as adults are likely to do (Bergström et al., 2012). However, the construction phase is a relatively short phase and the volumes of suspended materials from, for example, drilling can be reduced in various ways. Particles are also transported away with currents and dissipated over large areas, which means that their impact is expected to be limited (Didrikas & Wijkmark, 2009). Where necessary, technical or other mitigation measures may be taken to minimise the impact on fish.

During the construction phase, increased noise levels may also occur which could affect the orientation sense of fish, their location of prey, communication and recruitment. If the sound levels are high enough, they can cause temporary or permanent damage to the hearing organs and the swim bladder and other internal organs (Andersson et al., 2016). Some surveys prior to the construction phase may lead to temporary avoidance behaviour in the vicinity of the survey vessel for certain species such as cod. Sound from the construction phase is considered to have the greatest impact on cod during the spawning period (Hammar et al., 2014). Within and in the vicinity of the farm area there are no active cod spawning grounds that could be affected. However, there are known spawning areas for sprat and possible spawning areas for flounder (HELCOM, 2020). Any impact on these populations will be investigated in the future environmental impact assessment.

Construction of foundations can lead to changes in habitats that can have a positive effect on the composition of fish communities through the creation of the so-called reef effect. Fish are usually attracted to structures (Wright et al., 2020) and the more complex the structures are, the more fish accumulate at them (Hammar et al., 2008b).

During the operational phase, noise (<700 Hz) is emitted from the turbines which may cause certain behavioural reactions in fish and mask fishes' own sounds (Popper et al., 2019). However, accumulations of fish observed around foundations following establishment of wind power facilities indicates that the potential impact of noise during the operating phase is of minor importance (Bergström et al. 2013; Stenberg et al. 2015).

There are several studies that show that if marine areas are protected from fishing, there are clear measurable effects with increased quantities of fish (Öhman et al., Roberts et al., 2001; Kamukuru et al.; 2004; White et al., 2008). The farm could to some extent protect fish populations in a similar way.

During the operating phase, electromagnetic fields occur around marine cables that could affect fish such as eels (Öhman et al., 2007; Westerberg et al. 2007; Westerberg and Lagenfelt 2008). Studies of the effect of cables on eels in the Lillgrund wind farm could not demonstrate any behavioural change, but a certain tendency toward increased movement time when there were higher currents in the cable was observed. A study on trout shows that roe can be adversely affected by electromagnetic fields but that the effects on larvae are marginal (Fey et al., 2019). Other studies have failed to demonstrate any significant effect of marine cables on fish (Dunlop et al., 2016). The overall impact of marine cables on fish is expected to be limited.

As a result of hydrogen production in the Pleione Energy Farm, Pleione Energipark AB is investigating whether the oxygen produced during the hydrogen process can be added to the bottom water during the operational phase. This could potentially oxygenate the deep anaerobic and oxygen-poor bottom waters of the eastern Gotland Basin adjacent to Pleione. This may in turn lead to the return of demersal organisms, or fish that repeatedly find their way down to the bottom, to the area due to increased access to food, infauna and bottom fauna. Salinity and temperature may also change, but probably to a limited extent. The impact of hydrogen production will be analysed in the forthcoming environmental impact assessment.

During the decommissioning phase, effects in the form of sediment dispersal, sedimentation and elevated sound levels may occur, but to a lesser extent than in the construction phase. Any positive effects from oxygenation and reef effects will disappear when the operation is dismantled.

6.3.4 Birds

The main effects that wind power can have on birds are:

- Barrier effects – that birds avoid areas with wind turbines, which creates barriers in the seascape that birds are forced to detour around,
- Displacement effects – that birds avoid wind turbine areas and therefore lose suitable areas for foraging, nursing, rest, etc.; and
- Collisions – birds colliding with wind turbines and being injured or killed.

The following briefly describes these influence factors for birds linked to the construction, operation and decommissioning phases of the operation. During the construction and decommissioning phases, birds will mainly be affected by increased boat traffic, which can lead to some barrier or displacement effects. However, the greatest impact normally occurs during the operational phase of a wind farm, so potential effects during the operational phase are described below. For future environmental impact assessments, counts and modelling will be carried out to assess the impact on birds.

Displacement effects mean that a species avoids the energy farm or its surroundings. The impact of displacement effects varies between species where, for example, long-tailed ducks have been shown to avoid wind farms to a large extent, while other seabird species seem unaffected (Nilsson & Green, 2011; Fox & Petersen, 2019).

Collision risk means that birds are injured or killed as a direct result of colliding with the turbine blades or the turbulence that occurs behind the blades. An important factor in assessing the risk of collision is the flight height of the different species.

The barrier effect means that the energy farm forms an obstacle to passing birds. Although this effect reduces the risk of collision, it increases the energy consumption of birds because they risk having to change their flight route to avoid the farm.

During the spring, millions of birds pass through Gotland, especially the southern tip of the island, and then fly in a north-eastern direction toward the Baltic and the Gulf of Finland. In the autumn, this migratory bird route goes in the opposite direction. Potential barrier effects and collision risks during the spring and autumn will be investigated. Potential displacement effects, barrier effects and collision risks during the breeding period, as well as for overwintering birds, will also be investigated.

6.3.5 Bats

The operation is not expected to have any impact on bats during the construction and decommissioning phases. During the operational phase, bats can be affected by the risk of colliding with the rotor blades and thus being injured or killed. During migration, bat species found in Sweden generally fly at low altitude above the sea, which minimises the risk of collision with the wind turbine rotor blades (Ahlén et al., 2009). However, when bats come in contact with high objects they may increase their flight altitude, which increases the risk of collision. Foraging and migration of bats over the sea take place in relatively warm and calm conditions (Ahlén et al., 2007; Ahlén et al., 2009). Counts using ultrasound detectors are made in connection with marine biological surveys in the farm area during 2023 and 2024.

Pleione is too far from land for bats to be expected to use the area for foraging. Bats may, on the other hand, pass through the farm area during spring or autumn migration.

6.3.6 Marine mammals

Underwater noise can affect marine mammals. Its impact depends on a number of factors such as the intensity and frequency of sound, whether the sound is in the form of impulses or continuous, the salinity of water, bottom conditions, the distance to the sound source, and the hearing spectrum and sensitivity of the animals. Higher noise levels may result in avoidance behaviour. If marine mammals do not avoid the area and instead are continuously exposed to high sound levels, there is a risk of temporary hearing loss (Temporary Threshold Shift, TTS) and then permanent hearing loss (Permanent Threshold Shift, PTS).

The construction phase is the period that will generate the most noise. Noise emissions may come from several different sources, including from ships, surveys and work in the form of pile driving, for example. Mitigation measures such as bubble curtains, soft-start equipment and restriction periods can be used to limit the impact on marine mammals. Noise levels will be modelled and the potential impact, as well as the need for mitigation measures, will be investigated in future environmental impact assessments.

During the operational phase, the wind turbines can emit low-frequency sounds. In previous studies, however, this has not appeared to have a negative impact on either seals or porpoises, which in the operational phase have returned to the farm area to at least the same extent as before. During the operational phase, hydrogen production within the Pleione Energy Farm will result in the discharge of cooling water and brine, which can locally affect the water temperature and its salt content. However, this effect is expected to be minimal, as discharges are rapidly diluted in the surrounding water masses.

As previously described, oxygen is formed during hydrogen production process, which could potentially be released at the seabed in deep anaerobic and oxygen-poor parts. This could potentially have a strong positive effect on the bottom environment and fish species living under the salt halocline, which in turn can also have a positive impact on marine mammals. When the foundations for energy production plant are installed, it means that hard substrates are added, which can contribute to habitats for sessile animals, a so-called reef effect. This can attract fish wishing to feed at the foundations, which in turn can also attract marine mammals to also feed around the foundations (Bergström et al., 2012; Russell et al., 2014).

In the decommissioning phase, impacts occur similar to those in the construction phase with underwater noise and sediment dispersal, but to a lesser extent. Any positive effects from oxygenation and reef effects will disappear if the operation is dismantled.

6.3.7 Green infrastructure for biodiversity and ecosystem services

Several different forms of ecosystem services can be expected to develop around the farms during the operational phase. The formation of reefs around the foundations may lead to the establishment of filtering organisms (Andersson & Öhman, 2010), which could locally create a potentially regulating ecosystem service in the form of locally improved water quality (McLaughlan & Aldridge, 2013). The increase in filtering and photosynthetic organisms around the foundations can contribute to an aggregation of fish that could benefit the fishing industry (supplying ecosystem services) (Grove et al., 1989).

Better habitats for commercial species combined with reduced trawling would benefit coastal fishing, which could also provide an important cultural ecosystem service for the local area. The impact on ecosystem services and possible measures to minimise impacts and promote local ecosystems will be investigated in the development of the environmental impact assessment.

Oxygenation

Pleione Energipark AB is currently investigating the conditions for combining hydrogen production within the Pleione Energy Farm with oxygenation of the bottom water in the eastern Gotland Basin, where the bottom water is completely anaerobic. In the past, it was one of the cod's reproduction areas in addition to the Western Gotland Basin, the Bornholm Basin and the Gdansk Deep, now there is limited cod reproduction at the Bornholm Basin as the spread of anaerobic bottoms has increased in the central and southern Baltic Sea.

Oxygenation of the eastern Gotland Basin is expected to have positive impacts on biodiversity, as it could contribute to the re-colonisation of demersal animals such as saduria entoman, which in turn would stimulate fish production. Demersal animals are an important source of food for a range of fauna, including cod, herring and flatfish. Oxygenation of the bottom water also has the potential to reduce the internal phosphorus source, which would be positive because phosphorus is the dominant nutrient causing large-scale eutrophication in the Baltic Sea. Oxygenation of the bottom water will improve sediment's ability to retain phosphorus (Stigebrandt, 2021).

The oxygenation of the seabed will be further investigated and described in the future environmental impact assessment.

Nature-inclusive design

Nature-inclusive design will contribute to the ecological function of native species, with a focus on strengthening the position of endangered species and habitats. The starting point is that the measures should primarily be based on available technology that has been previously tested with good results. The ecological benefits are difficult to quantify in the initial stages, so that monitoring after implementation is recommended. In order to determine the opportunities and needs for protection, a more detailed analysis is needed to identify the site-specific need and the target species. Offshore wind power provides an opportunity to increase biodiversity through, among other things, the creation of hard substrates, such as erosion protection and foundations. The foundations of the wind and energy farms add hard surfaces that sessile animals, such as mussels, can potentially use as habitat, which can increase biodiversity locally. Fish have also been observed foraging around wind power foundations.

In addition to nature-inclusive design, tests will be carried out with artificial reefs and structures for fish as well as the potential for blue mussel farming. This will be investigated further and described in the future environmental impact assessment.

6.4 Landscape scenery

Wind turbines affect the visual impression of the land or seascape they are in. Pleione is located at sea, about 37 kilometres from Gotland. The planned turbines have an overall height of maximum 370 metres. The wind turbines will therefore be visible from a large distance from open spaces in the surrounding seascape or from high locations on shore. On days with good visibility, the energy farm will be visible from Gotland during its operational phase. Furthermore, wind turbines with a total height of more than 150 metres need to be marked with obstruction lighting, which can increase visibility for the turbines at night.

The wind turbines will only be visible from Gotland, regardless of design options and their overall height. Visualisations and photo-montages have been created from several vantage points in Sweden in order to demonstrate the expected seascape view after the establishment of the energy farm. In the context of the environmental impact assessment, so-called visibility analyses will also be produced, which will show from which places in the surrounding sea and landscape wind turbines will be visible.

6.5 Commercial fishing

During the construction phase, safety distances to construction activities will apply, which may affect commercial fishing by loss of available areas to fish in and longer transport distances. During the operational phase, wind farms usually entail that the area becomes a fishing-free zone, although no formal ban on fishing applies within the farm. This is because of the nature of currently used fishing gear. If new gear is developed, wind farm areas can potentially be used for commercial fishing in the future. There is currently hardly any trawl fishing at the Pleione farm area currently, which means that an establishment there is not expected to entail a loss of any significant area used for fishing. The impact during the decommissioning phase is expected to be similar to that at the construction phase, where the safety distance to the works means loss of fishing areas and longer transport distances.

Pleione Energipark AB is investigating the possibility of releasing oxygen generated from hydrogen production in deep anaerobic and oxygen-poor areas of the seabed in Pleione, which may have a positive effect on fish stocks in the longer term. This, together with reef effects and the fact that energy farms in practice often become fishing-free zones, can also result in spill-over effects, and benefit commercial fishing in adjacent areas.

The impact on fishing will be further described in future environmental impact assessments.

6.6 Climate

The construction of the energy farm will have a certain climate impact in the form of the production of wind turbines and other installations, transport and installation work. The decommissioning phase also involves a certain climate footprint linked to vehicle operation and so on. These activities will be limited in time and scope. During the operational phase, the energy farm will instead contribute with fossil-free energy. Electricity production in the farm would have a capacity of about 5 TWh, which is equivalent to the capacity to supply up to 1 million households with renewable electricity. In other words, the energy farm would play a central part in limiting future climate change and switching to a renewable electricity system. The impact of the farm on the climate will be further explained in the future environmental impact assessment.

6.7 Infrastructure and planning conditions

6.7.1 Maritime activities

During the construction and decommissioning phase of the energy farm, disturbances to shipping may occur due to increased boat traffic and possible closures within the farm area. However, the disturbances will be temporary and limited to the time that the construction work is ongoing.

As the energy farm is located so as not to overlap with designated shipping lanes, the risk of conflict during the operational phase is assessed as low and the impact is expected to be limited. However, an establishment may lead to an increased risk of collision, especially during days with conditions of reduced visibility. A safety distance should be created from the outer wind turbines in the farm to the nearby shipping lanes, so as not to endanger the safety of vessels (Swedish Transport Agency, 2023). As the farm area is located next to two busy shipping lanes, the maritime risks will be investigated in more detail with a more detailed risk analysis for shipping in the future environmental impact assessment.

6.7.2 Aviation

New obstacles within an MSA area can have negative consequences on air traffic and require a revision of the flight altitude in the current MSA area. As Pleione does not overlap with any MSA area from Visby Airport, the energy farm is not expected to have any impact on aviation in this respect.

Visby Airport is a military airport and is thus a designated site of national interest for the Swedish Armed Forces (Swedish Armed Forces, 2019).

The flight operations of the Swedish Armed Forces may also be affected in the form of restrictions such as flight altitudes and/or airways. However, the farm area does not overlap with any designated low-flight area or the operations of the Swedish Armed Forces with regards to aviation. Aviation should therefore not be affected during the various stages of establishment. Potential impacts and interactions with stakeholders will be further investigated before future environmental impact assessments.

6.7.3 Military areas

The Swedish Armed Forces' naval exercise area of national interest is located north of Pleione. Otherwise, the energy farm does not border any further sea exercise areas, neither belonging to Sweden nor to other countries.

Objects higher than 20 metres risk affecting the national interest of the Swedish Armed Forces. Wind turbines can, among other things, have a negative impact on the Swedish Armed Forces' radar system, radio links, signal reconnaissance, flight operations, and exercise and shooting operations. A dialogue on co-existence will be conducted with the Swedish Armed Forces.

6.7.4 Environmentally hazardous objects and dumping areas

Within Pleione there is a known area with an elevated risk of the occurrence of sunken mines. Prior to the construction of the energy farm, magnetic field surveys will be carried out to detect any mines. The risk assessment regarding mines will be considered further in the forthcoming environmental impact assessment.

6.8 Resource management

The winds overseas are often both stronger and more even than over land, which makes it possible to build larger and more efficient farms (Boverket, 2022). The use of the winds at sea for energy production thus entails a good management of natural resources.

Wind turbines are made up of components that, among other things, contain metals, as well as concrete foundations. According to the Swedish Energy Agency (2021), emissions from manufacturing, raw materials, assembly, maintenance, disassembly and recycling are the ones that make up wind power's combined impact per kWh produced. It takes about six months for an onshore wind turbine to produce the same amount of energy as was required to produce it (Swedish Energy Agency, 2021).

When decommissioning the energy farm, dismantled wind turbines can be renovated and resold for reuse if a demand exists, or the components of the wind turbines can be recycled. The resources employed to produce the wind turbines can thus continue to be used, even after the energy farm has been phased out.

6.9 Cumulative effects

Cumulative effects refer to the effects of other activities or measures that may have environmental effects within the impact area of the project in question. Cumulative effects can occur when several different effects interact with each other, both when different types of effects from one and the same activity interact or if effects from different activities interact. Cumulative effects may include, for example, impacts on birds, fish and marine mammals from various types of activity within a specified geographical area.

A starting point for assessing cumulative effects is to include existing and permited activities located near the farm area, which may potentially affect the same environmental aspects as relevant farms.

OX2 sees great advantages in the parallel development of the farm areas of Pleione and Ran, which is located about 20 kilometres west of Pleione, as the environmental impact assessments will consider the common environmental impacts and any cumulative effects that may arise. A separate notification and environmental impact assessment will be prepared for the Ran wind farm.

The environmental impact assessments will include potential cumulative effects from other activities in the area, such as those from shipping, pipelines, cables and other activities.

7. Potential transboundary impacts

The environmental impact assessment that is prepared in accordance with Article 4 of the Espoo Convention will assess and describe the expected transboundary impacts. The main transboundary impact that could arise is set out in this chapter.

7.1 Birds

The potential impact on birds described in section 6.3.4 may extend beyond the Swedish EEZ, since certain species of birds move over very large areas and are therefore found within the maritime territories and zones of multiple countries. Further studies will be carried out in 2023 to provide more detailed information on migratory birds' movements during spring and autumn migrations regarding the direction of flight, altitude and number of species in or near the farm area. The impact on birds will be described in the future environmental impact assessment.

7.2 Marine mammals

Porpoises, grey seals and common seals are identified species in several Swedish, Polish, German and Danish Natura 2000 sites. The potential impacts described in section 6.3.6 may extend beyond the Swedish border, since the areas these species occur in may comprise parts of the territory of several countries. The impact on marine mammals in the Swedish EEZ is expected to be limited, which means that the potential transboundary impact can also be expected to be limited. The impact on marine mammals will be described in the future environmental impact assessment.

7.3 Biodiversity

The positive effects from possible oxygenation and nature-inclusive design described in section 6.3.7 can potentially also have a transboundary impact. This impact will be described in the future environmental impact assessment.

7.4 Landscape scenery

The effects on the land and seascape in Sweden's economic zone will be investigated through future visibility analyses. However, as the nearest mainland outside the economic zone of Sweden (Latvia) is located just over 100 km from Pleione, the transboundary impact is expected to be limited. The impact on the land and seascape will be described in the future environmental impact assessment.

7.5 Fishing

The preliminary environmental impact discussed in section 6.5 may also have transboundary implications for commercial fishermen from Latvia. The impact on fishing in the farm area, both regarding Swedish and international fishing, is expected to be limited, although it cannot be excluded that individual fishermen may be affected by the planned energy farm. The impact on fishing will be described in the future environmental impact assessment.

7.6 Maritime activities

The preliminary environmental impact shown in section 6.7.1 may also involve a transboundary impact, mainly in the form of temporary effects on the maritime traffic in the area due to increased boat traffic and possible closures in the project area during the construction phase. The planned energy farm borders on two shipping lanes and there is a risk of impact on shipping in the form of increased collision risk and accidents linked to the production of hydrogen gas. A nautical risk analysis will be carried out and the risk to shipping will be considered in the forthcoming environmental impact assessment.

7.7 Cumulative effects

As described in Section 6.9, cumulative assessments will be carried out for the existing and permitted activities located in the vicinity of the farm area. The environmental impact assessment will include a consideration of the cumulative effects from other activities in the area, such as those from shipping, pipelines, cables and other existing activities and activities for which permits have been granted.

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8.2 References for databases for maps

Metria

https://metria.se/

Lantmäteriet (the Swedish mapping, cadastral and land registration authority)

https://www.lantmateriet.se/

Swedish Environmental Protection Agency

https://www.naturvardsverket.se/

County Administrative Board

https://ext-geodatakatalog.lansstyrelsen.se/GeodataKatalogen/

EMODnet

Data used in this consultation dossier have been made available by EMODnet's Geology Project http://www.emodnet-geology.eu, funded by the Directorate-General for Maritime Affairs and Fisheries of the European Commission. The data was collected by the Finnish Geological Survey, GTK.

https://emodnet.eu/en/bathymetry

The Swedish Maritime Administration

https://www.sjofartsverket.se/sv/

Helcom

https://helcom.fi/