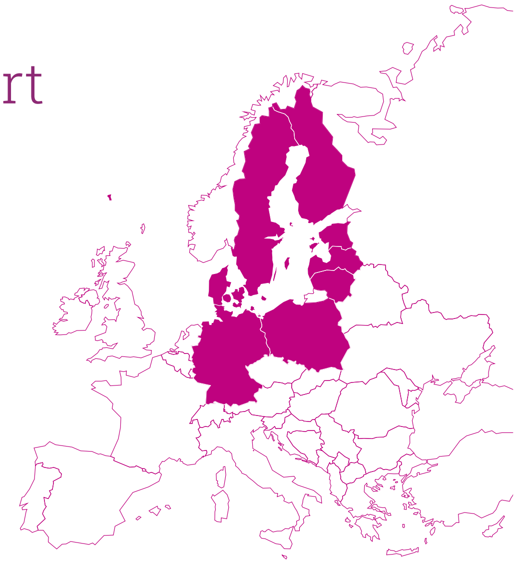
TYNDP 2024

Sea-Basin ONDP Report

TEN-E Offshore Priority Corridor: BEMIP Offshore Grids



January 2024

15 YEARS OF entsoe ELECTRIFYING EUROPE

ENTSO-E Mission Statement

Who we are

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the **association for the cooperation of the European transmission system operators (TSOs)**. The **40 member TSOs**, representing 36 countries, are responsible for the **secure and coordinated operation** of Europe's electricity system, the largest interconnected electrical grid in the world. In addition to its core, historical role in technical cooperation, ENTSO-E is also the common voice of TSOs.

ENTSO-E **brings together the unique expertise of TSOs for the benefit of European citizens** by keeping the lights on, enabling the energy transition, and promoting the completion and optimal functioning of the internal electricity market, including via the fulfilment of the mandates given to ENTSO-E based on EU legislation.

Our mission

ENTSO-E and its members, as the European TSO community, fulfil a common mission: Ensuring the **security of the inter-connected power system in all time frames at pan-European level and the optimal functioning and development of the European interconnected electricity markets**, while enabling the integration of electricity generated from renewable energy sources and of emerging technologies.

Our vision

ENTSO-E plays a central role in enabling Europe to become the first **climate-neutral continent by 2050** by creating a system that is secure, sustainable and affordable, and that integrates the expected amount of renewable energy, thereby offering an essential contribution to the European Green Deal. This endeavour requires **sector integration** and close cooperation among all actors.

Europe is moving towards a sustainable, digitalised, integrated and electrified energy system with a combination of centralised and distributed resources. ENTSO-E acts to ensure that this energy system **keeps consumers at its centre** and is operated and developed with climate objectives and **social welfare** in mind.

ENTSO-E is committed to use its unique expertise and system-wide view – supported by a responsibility to maintain the system's security – to deliver a comprehensive roadmap of how a climate-neutral Europe looks.

Our values

ENTSO-E acts in **solidarity** as a community of TSOs united by a shared **responsibility**.

As the professional association of independent and neutral regulated entities acting under a clear legal mandate, ENTSO-E serves the interests of society by **optimising social welfare** in its dimensions of safety, economy, environment, and performance.

ENTSO-E is committed to working with the highest technical rigour as well as developing sustainable and **innovative responses to prepare for the future** and overcoming the challenges of keeping the power system secure in a climate-neutral Europe. In all its activities, ENTSO-E acts with transparency and in a trustworthy dialogue with legislative and regulatory decision makers and stakeholders.

Our contributions

ENTSO-E supports the cooperation among its members at European and regional levels. Over the past decades, TSOs have undertaken initiatives to increase their cooperation in network planning, operation and market integration, thereby successfully contributing to meeting EU climate and energy targets.

To carry out its **legally mandated tasks**, ENTSO-E's key responsibilities include the following:

- Development and implementation of standards, network codes, platforms and tools to ensure secure system and market operation as well as integration of renewable energy;
- Assessment of the adequacy of the system in different timeframes;
- Coordination of the planning and development of infrastructures at the European level (**Ten-Year Network Development Plans, TYNDPs**);
- Coordination of research, development and innovation activities of TSOs;
- Development of platforms to enable the transparent sharing of data with market participants.

ENTSO-E supports its members in the **implementation and monitoring** of the agreed common rules.

ENTSO-E is the common voice of European TSOs and provides expert contributions and a constructive view to energy debates to support policymakers in making informed decisions.

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ENTSO-E ONDP interactive data visualisation platform

Questions?

Contact us as at **tyndp@entsoe.eu**

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Executive Summary

Key Messages for BEMIP offshore grids

The target of the Baltic energy market interconnection plan (BEMIP)[1] is to achieve an open and integrated regional electricity and gas market between EU countries in the Baltic Sea region. The BEMIP members are Denmark, Germany, Estonia, Latvia, Lithuania, Poland, Finland and Sweden.

The Offshore Network Development Plan (ONDPs) deliver a high-level outlook on offshore generation capacities potential and resulting offshore network transmission needs for each sea basin. The amended TEN-E regulation (EU-reg. 2022/869) appointed ENTSO-E as a responsible body for the development and planning of the offshore network from now until 2050. The ONDP 2024 initiated and prepared by Member State (MS) Transmission System Operators (TSOs) under ENTSO-E is a starting point for identifying new potential offshore transmission corridors and high-level requirements in offshore network growth up to 2050. As the ONDP 2024 is the first step towards developing a potential offshore grid, it provides strategic insights into determining new offshore connections. The ONDP 2024 is the first application of a new approach and provides a first overview of the potential method to plan an offshore network in the BEMIP area. The ONDP 2024 provides high level information on the possible opportunities to efficiently integrate the capacities in line with the non-binding agreements on goals for the offshore renewable generation of the MSs of the Baltic Region.

The ONDP 2024 consists of an umbrella document, a detailed description of the methodology and sea basin specific to the ONDPs, among others the present BEMIP ONDP. The sea basin specific ONDPs involve forecasted offshore wind production for the three time horizons 2030, 2040 and 2050, whereby the potential offshore wind development is delivered by the involved EU MSs and the current TSO forecasts. Based on this methodology, ENTSO-E has developed an overall view of the potential offshore infrastructure needed to realise the offshore wind ambitions.

According to the European Union's (EU) 2030 climate target plan and the EU's plan for a green transition: Fit for 55, greenhouse gas emissions must be reduced by at least 55 % from 1990 levels up to 2030.[2] In line with its targets, the EU has set ambitious objectives for renewable energy for all member states, expecting to develop at least 60 GW of offshore wind power by 2030 and 300 GW by 2050 in order to become the first continent to be carbon neutral. These goals are anticipated to be significantly aided by the BEMIP area, where several countries are actively exploring offshore wind potential and possible future projects.[3]

The ONDP 2024 for BEMIP focuses on determining necessary offshore infrastructure expansion, while the onshore grid requirement will be assessed in the TYNDP 2024 Identification of System Needs (IoSN) study, where, among other things, country-specific load adjustments compared to the TYNDP 2022 are considered. The ONDP offers a broad overview of the prospective future transmission corridors and suggests that additional offshore grids will be needed to develop offshore wind parks and meet EU carbon neutrality targets.

1 Baltic Energy Market Interconnection Plan

2 EU measures against climate change | News | European Parliament (europa.eu)

3 2030 Climate Target Plan

BEMIP offers 70 GW of offshore RES potential

The BEMIP region has great potential for producing offshore wind energy, which can advance the materialisation of Europe's ambitions for renewable energy. The Baltic Sea's size provides plenty of room for the installation of OWFs that can take advantage of the region's strong and reliable winds. The Baltic Sea basin covers an area of 377,000 square kilometres and includes several countries – Germany, Poland, Denmark, Sweden, Finland, Estonia, Latvia and Lithuania.[4] Numerous locations for the development of OWFs and offshore hubs as well as offshore energy islands and international connections can be found throughout its coastline and within the respective exclusive economic zones (EEZs). MSs had to deliver non-binding agreements on joint offshore RES goals to the European Commission (EC) in January 2023. Due to dynamic developments, these numbers have been updated for some countries by TSOs in collaboration with the respective ministries. TSO data show that offshore RES targets for 2050 sum up to close to 70 GW.

Mostly radial RES connection in 2040 with progressive development of hybrid infrastructure towards 2050

The ONDP 2024 is the first step to further developing a future offshore grid. The design of the offshore grid infrastructure is generally composed of different technologies (AC and DC) and designs: radial OWP connections, classical interconnections and new types of infrastructure, so-called offshore hybrid projects such as the Krieger's Flak Combined Grid Solution. This first BEMIP offshore grids ONDP edition focuses on identifying possible connection configurations and assets needed to integrate the offshore RES associated with the MSs' non-binding targets. This is a first high-level step in the value chain of offshore development, which will be followed by market parties' investigations translating transmission corridors to projects and then more detailed assessments leading to the concrete design choices and projects. The modelling exercise was done for the two TYs 2040 and 2050. Further information on the methodology can be found in the "Methodology Document".

By 2030, the majority of projects will be connected radially, and a few hybrid projects are expected to be under development phase. Some of them have already been communicated in the TYNDP 2022. The total offshore wind capacity according to the targets of the BEMIP countries in 2030 is about 26.6 GW.

According to the TSO data offshore targets for 2040, it is expected that in the BEMIP region the installed capacity could reach 44.9 GW. Similar to 2030, in 2040 most of the offshore RES will be connected radially, but new cross-border offshore hybrid projects are being developed. The identified offshore transmission corridors are leading in the direction from north-east to south-west. Depending on the technology and configuration, up to two additional corridors have been identified, with a total capacity of 3 GW and a total length of 875 km.

In 2050, the grid is forming its shape and more hybrid connections between different countries could be established, and the potential length of hybrid connections will increase. The identified offshore transmission corridors are leading in the direction from north-east to south-west and from east to west. Depending on the scenario, up to nine corridors were chosen. This would add 2,408.5 km of additional infrastructure to the grid in 2050. The BEMIP offshore grids in 2050 will have up to 70 GW of offshore wind capacity installed according to the TSO data. Due to dynamic developments, the numbers have been updated for some countries by TSOs in collaboration with the respective ministries.

4 Baltic Sea | The European Maritime Spatial Planning Platform (europa.eu)

1 Introduction to the Sea Basin Report BEMIP Offshore Grids

On 3 June 2022, the revised TEN-E regulation (EU) 2022/869 entered into force, mandating ENTSO-E with the new task of developing offshore network development plans (ONDPs) for each sea basin by 24 January 2024. Formally, the ONDPs are a separate part of ENTSO-E's TYNDP.

The offshore plans must be built on the joint MSs' non-binding agreements on joint offshore RES goals for each sea basin. On 19 January, EU countries, with the support of the EC, concluded regional non-binding agreements to cooperate on goals for offshore renewable generation to be deployed within each sea basin by 2050. These agreements include intermediate steps in 2030 and 2040[5,6]. The ONDPs deliver a high-level outlook on offshore generation capacities potential and resulting offshore network infrastructure needs for each sea basin. The sea basins and involved countries are laid down in the regulation and shown in Figure 1.

More detailed information on the legal framework is provided in the [Pan-European Offshore Network Transmission Needs report](). Information on the methodology used to elaborate this plan can be found in the [Methodology Report]().

Priority Offshore Grid Corridors

1 Northern Seas Offshore Grids (NSOG)
2 Baltic Energy Market Interconnection Plan (BEMIP offshore)
3 Atlantic Offshore Grids (AOG)
4 South and West Offshore Grids (SW offshore)
5 South and East Offshore Grids (SE offshore)

ENTSO-E Member
ENTSO-E Observer Member

TEN-E Priority Offshore Grid Corridors	Countries involved
1. NSOG	BE, DK, FR, DE, IE, LU, NL, SE
2. BEMIP offshore	DK, EE, FI, DE, LT, LV, PL, SE
3. AOG	FR, IE, PT, ES
4. SW offshore	FR, GR, IT, MT, PT, ES
5. SE offshore	BG, CY, HR, GR, IT, RO, SI

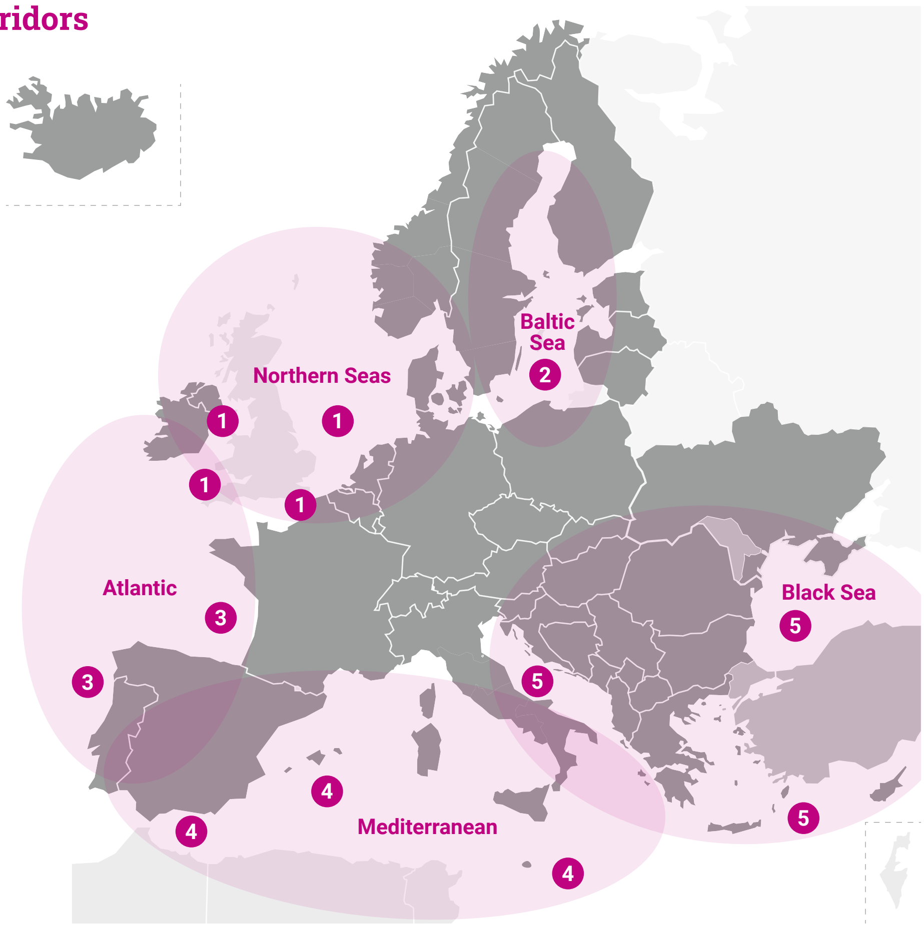

Figure 1 – TEN-E Priority Offshore Grid Corridors as laid down in Regulation (EU) 2022/869.

5 https://energy.ec.europa.eu/system/files/2023-01/BEMIP_non-binding_offshore_goals_final.pdf
6 https://energy.ec.europa.eu/news/member-states-agree-new-ambition-expanding-offshore-renewable-energy-2023-01-19_en

2 Member States' non-binding Agreements on Goals for Offshore Renewable Generation

The non-binding agreement on goals for offshore renewable generation have been provided by the EU MSs to the EC, who collected a list of non-binding goals per MS and sea basin for each reference year.

Some MSs delivered a range; in these cases, as a standard approach, ENTSO-E used the upper boundary, unless more detailed information is available. This was done to provide the full picture of a potential offshore network infrastructure. The numbers are shown in Figure 1. Due to dynamic developments, the numbers have been updated for some countries by TSOs in collaboration with the respective ministries. Differences between MS data and TSO data are described in the following paragraphs by country, specifically after the table.

Applying upper limits				TSO data status 6.4.2023							
MS 20.1. [GW]	2030	2040	2050	ONDP Data [GW]	2030	2040	2050	Delta [GW]	2030	2040	2050
DE	4.1	4.1	4.1	DE	4.15	4.15	4.15	DE	0.05	0.05	0.05
DK	7.9	7.9	7.9	DK	7.98	7.90	7.90	DK	0.08	0.0	0.0
EE	1.0	3.5	7.0	EE	1.00	3.50	7.00	EE	0.0	0.0	0.0
FI	1.0	5.0	12.0	FI	1.00	4.90	12.00	FI	0.0	−0.1	0.0
LT	1.4	2.8	4.5	LT	1.40	2.80	4.50	LT	0.0	0.0	0.0
LV	0.4	0.4	0.4	LV	0.5	1.5	2.5	LV	0.1	1.1	2.1
PL	10.1	10.9	10.9	PL	10.1	10.90	10.90	PL	0.0	0.0	0.0
SE	0.7			SE	0.60	9.20	21.20	SE	−0.1	9.2	21.2
TOTAL	**26.6**	**34.6**	**46.8**	**TOTAL**	**26.73**	**44.85**	**70.15**	**TOTAL**	**0.13**	**10.25**	**23.35**

Table 1 – Offshore RES capacities: left: upper range delivered by the MSs.

Denmark

The ONDP data for Denmark are based on the official data from the Danish Energy Agency (DEA), which is used by the Danish TSO for planning purposes. These data are consistent with the capacity included in the Marienborg Declaration[7]. The targets in 2030 include approximately 1,500 MW of existing offshore wind resources. New resources include 3 GW of offshore wind at the Bornholm Energy Island and an additional 3 GW from the political agreement "Klimaaftale om grøn strøm og varme" from 25 June 2022, in addition to capacity from a number of potential radial projects.

Estonia

The ONDP data included for Estonia's wind farm development is a non-binding agreement and Estonian vision for the future that has also been considered in the TYNDP report. By 2030, the Estonian government expects renewable energy to supply all of its energy needs. The Marienborg Declaration declared that by 2030, Estonia will have 1 GW of built OWF capacity.[8]

Finland

The ONDP data are based on Finland's preliminary official non-binding targets for offshore wind that were published in early 2023. Finland has the target of being carbon neutral by 2035. Offshore wind is seen as one of the factors enabling this, and the increase in offshore wind is expected to happen especially in 2030s and 2040s in Finland.

The preliminary targets for Finland have been translated to offshore capacities by the TSO so that the target is divided into 1.3 GW projects, corresponding to the maximum allowed capacity of a single generation project in Finland. The expectation here is that there is one 1 GW project in 2030 and one 0.6 GW project in 2050. In the TSO data there are ten projects by 2050, four by 2040 and one by 2030. Projects are geographically located along the coastal line in both territorial waters and the EEZ zone, following energy generation areas indicated in the maritime spatial plan (MSP). By 2050, it is expected that the projects will also be allowed to locate in southern sea areas, which are today restricted due to military reasons.

Offshore wind connections are assumed so in the ONDP projects located less than 60 km for the coastal line will be connected with AC submarine cables, and those located farer away, with high-voltage direct current (HVDC) cables. Practically, DC connectable projects are located in the southern sea areas and north from Åland Islands.

Germany

Germany aims to achieve 30 GW of offshore wind by 2030 and 40 GW by 2035. By 2045, the goal is to generate at least 70 GW. Most of the capacity will be located in the North Sea. For the non-binding agreement on goals for offshore renewable generation in 2050 with intermediate steps in 2030 and 2040, the German ministry reported a capacity of 4.1 GW for all target years in the German Baltic Sea. However, these numbers do not reflect the additional 1 GW offshore wind capacity that is assumed to be built in the German Baltic Sea after 2030 and until 2045 by the most recent German National Grid Development Plan.

7 The Marienborg Declaration (regeringen.dk)

8 Steps towards increasing the energy security of the Baltic region have been agreed in Marienborg | Eesti Vabariigi Valitsus

Latvia

The ONDP data are a best estimate by the TSO regarding all possible developments and offshore wind potential in Latvia (max potential estimated around 14 GW). The MS data 0.4 GW is presented only for the 2030 time horizon, and the rest of the values have been kept the same for all other time horizons. According to Latvian TSO data, which have been harmonized with the Latvian ministry of Climate and Energy, the offshore wind in 2030 can reach a capacity of 0.5 GW. For 2040 and 2050, it the best estimate forecast from the Latvian TSO. In 2050, at least part of Latvian offshore wind potential (realised 2.5 GW) could be realised to contribute to the decarbonisation goals of the EU. The offshore wind developments could be even higher as presented right now in the table.

Lithuania

For the ONDP, the development of offshore wind capacity under non-binding targets agreement of the development of offshore wind is used. For 2030, the goal of reaching 1.4 GW of offshore wind capacity is already underway – the first auction for a 0.7 GW offshore wind farm has already taken place, and the second auction for another 0.7 GW is planned for January 2024. By 2050, Lithuania sees opportunities to exploit the full 4.5 GW offshore wind potential as Lithuania seeks to become one of the offshore energy hubs combining offshore wind and hydrogen technologies and become an exporter of energy products.

Poland

New regulations have been adopted in Poland, which will significantly facilitate the use of the wind energy potential in the Baltic Sea and the development of Polish companies from the maritime sector. The new act introduces a number of improvements. Administrative and legal procedures have been simplified, shortening the time in which investors can complete investments in offshore wind farms (OWFs). The new regulations will encourage investors and accelerate the process of transforming the Polish energy sector into zero-emission energy sources. In the first phase of the system's operation, for farms with a total capacity of 5.9 GW, support will be granted by way of an administrative decision by the President of the Energy Regulatory Office. In the following years, support will be granted in the form of competitive auctions. Based on The Energy Policy of Poland assumed development plans for OWFs include a support scheme up to 10.9 GW in total. So far, projects of a total capacity of 5.9 GW have received supporting contracts.

Sweden

Sweden has a technology-neutral national target and has communicated the offshore RES ambition regarding energy to the EC. This has been translated to capacity by the TSO. During the work on the ONDP in 2023, the MS and TSO agreed that the value applied by ENTSO-E can be used as a working assumption. Sweden's government has chosen not to deliver non-binding expansion targets for offshore wind power, except for the year 2030. This does not mean that no offshore wind power will be built at all in Sweden until 2050. Therefore, Svenska Kraftnät has proposed an expansion forecast that considers the energy target (expressed in TWh) established for the indicative Swedish offshore plans (approx. 30 GW). There will be a deviation between the TSO and MS data in 2030 (0.1 GW) because some small-scale regional grid-connected offshore wind power will then have been taken out of operation.

3 Offshore RES Capacities and Infrastructure Today

3.1 Existing electricity grid infrastructure in the BEMIP Offshore Grids

To achieve the goal of expanding an international offshore network, all existing projects as well as country-specific potential should be developed at this point. Already today, there are several completed offshore wind projects and subsea interconnectors in operation in the BEMIP region, which are shown in the following Figure 2.

Country	Project name	Capacity (MW)	Cable Length (km)	Commission year	Connection type
Germany	Baltic 1	48	77	2011	Radial
Germany	Baltic 2	288	136	2015	Radial
Germany	Ostwind 1	735	90	2020	Radial
Germany	Ostwind 2	723	100	2023/2024	Radial
Denmark/ Germany	Kontek	600	170	1995	Inter-connector
Denmark/ Germany	Combined Grid Solution*	400	25	2020	Hybrid
Denmark/ Sweden	Konti-Skan 1 & 2	714	150	Konti-Skan 1 1956/2006 Konti-Skan 2 1988	Inter-connector
Denmark	Tunø Knob	5	6	1995	Radial
Denmark	Middel-grunden	40	3.5	2000	Radial
Denmark	Frederik-shavn	7.6	<1	2003	Radial
Denmark	Samsø (2003)	20.7	6.5	2003	Radial
Denmark	Nysted	165.6	11	2003	Radial
Denmark	Sprogø	21	<1	2009	Radial
Denmark	Avedøre Holme (2009)	7.2	<1	2009	Radial
Denmark	Rødsand 2	207	10	2010	Radial
Denmark	Avedøre Holme (2011)	3.6	<1	2011	Radial
Denmark	Anholt (2012)	50.4	25	2012	Radial
Denmark	Anholt (2013)	349.2	25	2013	Radial
Denmark	Samsø (2018)	2.3	25	2018	Radial
Finland	Tahkoluoto offshore wind park	45	< 3	2010 and 2017	Radial
Finland	Ajos offshore wind park	30	< 3	2016 and 2016	Radial
Estonia/ Finland	EstLink 1	350	105	2006	Inter-connector
Estonia/ Finland	EstLink 2	650	171	2014	Inter-connector
Lithuania/ Sweden	NordBalt	700	450	2015	Inter-connector
Finland/ Sweden	FennoSkan 1	400	300	1989	Inter-connector
Finland/ Sweden	Fennoskan2	800	300	2011	Inter-connector
Finland/ Åland	Ål-link	100	152	2015	Inter-connector

* Combined Grid Solution connects the German wind farm Baltic 2 with the Danish wind farm Kriegers Flak, which are less than 30 km apart. The interconnector was established by connecting both wind farms by means of two submarine cables. The frequencies of the Danish and German transmission systems use a slightly different phase. That is why they need to be matched at the interface. This is enabled by means of two serial voltage source converters (VSC). This so-called back-to-back converter has been installed in Bentwisch, near Rostock. Due to the different voltage levels of the Danish and German offshore wind farms (150 to 220 kilovolt), a transformer is also required which has been installed on the Danish offshore platforms.

Table 2 – Existing projects in the BEMIP offshore grids corridor.

Krieger's Flak Combined Grid Solution – the first operational hybrid project

Together, Energinet and 50Hertz have implemented the first hybrid offshore interconnector in the Baltic Sea by linking the two national OWF connections. The so-called Kriegers Flak Combined Grid Solution (CGS) was commissioned in 2020 and connects the Danish region of Zealand with the German state of Mecklenburg-Western Pomerania. The transfer capacity is 400 MW.

The Combined Grid Solution is a hybrid system. On the one hand, it serves as the grid connection for the OWFs, on the other hand it connects the transmission grids of Denmark and Germany, thus, allowing for the transnational exchange of electricity. In the event of strong wind, the full capacity of submarine cables can be used to feed the wind power generated offshore into two grids via one single system. If there is relatively little wind on the Baltic Sea, however, the remaining capacity can still be used for the exchange of electricity between the two countries. Consequently, the platform and submarine cables are optimally used, regardless of the wind on the high seas. This type of hybrid system does not yet exist anywhere else in the world.[9]

9 Kriegers Flak – Combined Grid Solution (50hertz.com)

3.2 Country specific information about existing projects

Offshore wind in Denmark

Denmark is a member of both BEMIP and NSEC and has separated the offshore area into two: west and east of DK1. Denmark has a long history of developing OWFs, starting with a 5 MW project called Vindeby in 1991 and continuing with Horns Rev 1, the first large scale wind farm, installed in 2002. Today, Denmark has 13 existing OWFs, with a combined capacity of 1,485 MW in BEMIP. These are all radially connected projects.

The Danish government has ambitious goals for the green transition, and the development of green technologies at sea is a key tool for achieving these goals. New large OWFs and energy islands will help Denmark to comply with the Paris Agreement on the reduction of greenhouse gases and achieve the target of a 70 % reduction in CO_2 in 2030 and climate neutrality in 2050.

The Danish Government has decided that two energy islands shall be constructed in Danish waters: one in the Baltic Sea and another in the North Sea (see North Sea ONDP). The energy island on Bornholm will have a capacity of 3 GW, while the North Sea Energy Island will have a capacity of 3 GW in 2033, and 10 GW in the longer term. This is enough to meet the average electricity consumption of 6 million households.

In addition to the planned development of 3 GW offshore wind at Bornholm Energy Island, which will be a hybrid project, the Danish government has planned areas for new radial projects for up to an additional 3.5 GW in the Baltic Sea region. These projects are scheduled to be in operation by 2030. The blue areas in Figure 2 identify offshore areas reserved for existing and potential OWFs.

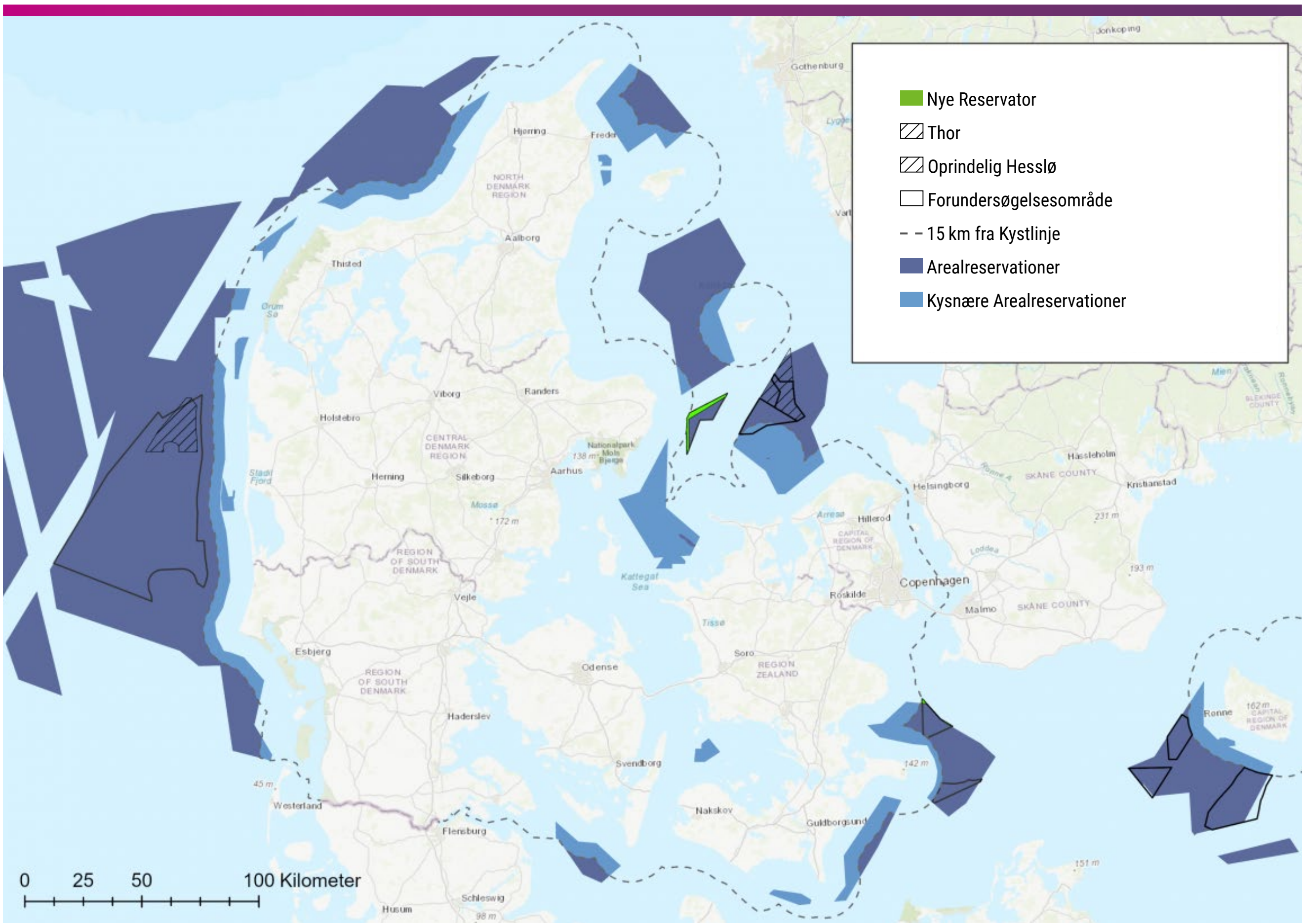

Figure 2 – Potential Danish windfarm areas.

Offshore wind in Estonia

Estonian OWF areas are located in the west coast of the country. According to the Estonian "National Energy and Climate Plan 2030", the Estonian maritime spatial plan has 1,295 km² of the suitable areas for offshore wind development located near the island Saaremaa. Near Pärnu area and Ruhnu and Kihnu islands there are 1,235 km² of suitable offshore wind areas. An area near the island Hiiumaa is indicated with the Hiiu maritime spatial plan that was cancelled on 8 August 2018 by the decision of the Supreme Court in case no. 3-16-1472.[10] According to Estonia's goals, 1 GW of OWFs will be connected to the Estonian grid by 2030, 3.5 GW by 2040 and 7 GW by 2050. The areas suitable for the development of wind energy are established by the Estonian marine area plan and are located in the Gulf of Livonia and on the coast of Saaremaa.

The potential for wind in various locations is as follows:

- Western coast of Saaremaa Island 6 – 13 GW;
- Coast of Kihnu island 3 – 6 GW; and
- Coast of Ruhnu island 3 – 7 GW.

The purple areas in Figure 3 show potential wind farm areas in Estonia.

[Information about the application for potential offshore renewable energy development projects in Estonian territorial waters can be found here.]

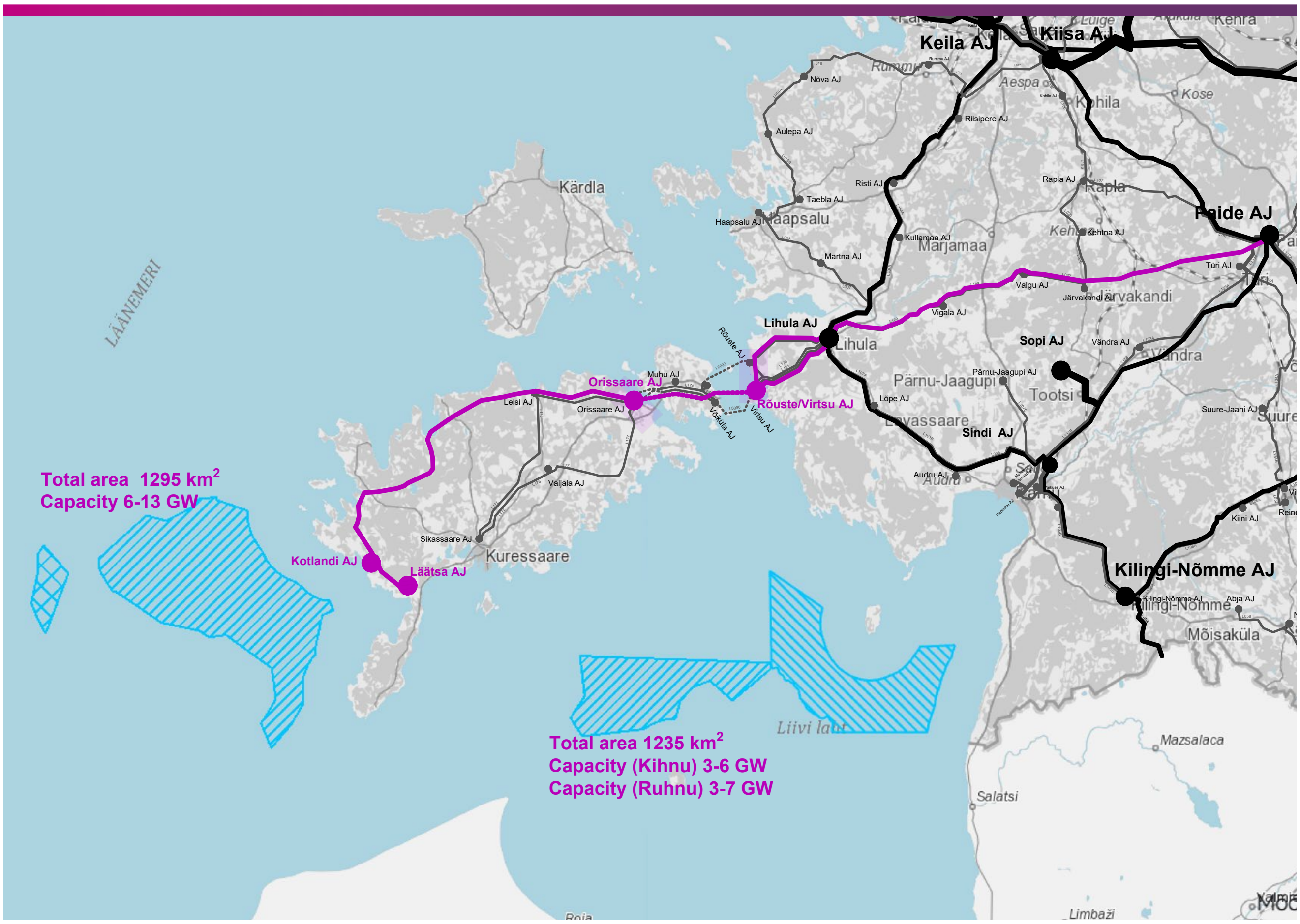

Figure 3 – Potential Estonian windfarm areas.

10 Superficies licences for offshore wind farms | Consumer Protection and Technical Regulatory Authority (ttja.ee)

Offshore wind in Finland

Finland has great potential for offshore wind as the country has an over 1100 km-long coastal line and wide sea areas. The Finnish sea areas consist of three different zones 1) territorial waters located closest to coastal line 2) exclusive economic zone (EEZ) bordered by neighbouring countries' sea areas and 3) territorial waters of the Åland Islands.

1. Metsähallitus controls the territorial waters of mainland Finland and is tendering areas for offshore wind. First tendering took place in 2022 and more tendering processes are planned for 2023 – 2024.

2. Some projects have been granted study permit in the EEZ zone recently but the legislation concerning, especially exclusivity in the EEZ zone, is currently unclear. Legislation is planned to be updated soon according to the new government programme.

3. Åland Island is an autonomous area and thus governs its own sea areas. Legislation and possible tendering process for offshore wind generation areas are under development.

Currently, offshore wind capacity installed in Finland is 73 MW, consisting of near shore installations with radial AC connection, but there are new connection inquiries of about 90 GW offshore wind projects. A major part of these projects is located in the Gulf of Bothnia in western sea areas of Finland. A couple of projects are also located in the territorial waters of Åland island. Military conflicts currently restrict the use of southern sea areas for offshore energy generation. Most of the projects can be connected with AC submarine cables as they are located quite close to the coastal line both on the territorial waters and EEZ of Finland.

In addition to offshore wind, Finland has remarkable potential for onshore wind, which is expected to be the dominant generation type in the coming years. The first large-scale offshore wind projects are expected to be realised around 2030. The green areas in the map below (see Figure 4) identify current public offshore wind projects' areas.

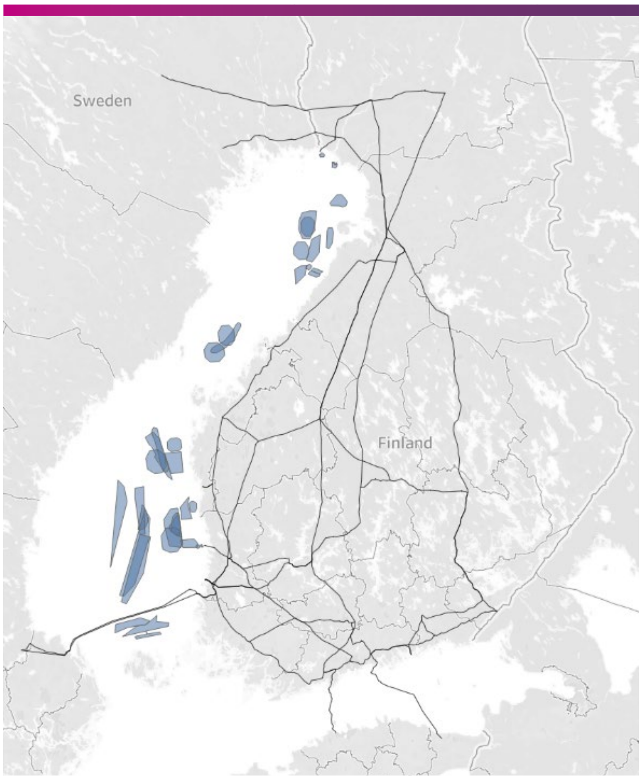

Figure 4 – Potential Finnish windfarm areas.

Offshore wind in Germany

Currently, there are OWFs with an accumulated capacity of ca. 1,100 MW operational in the German Baltic Sea. The Ostwind 2 project, with an additional 750 MW, is scheduled to become operational 2023/2024. The project pipeline of currently approved offshore wind projects in the German Baltic Sea accumulates to about 4.1 GW, including the already commissioned projects. All projects are expected to be operational by 2030. Subsequently, only 1 GW additional is assumed to be built in the German Baltic Sea until 2045 by the most recent German National Grid Development Plan. Furthermore, Germany and Denmark are jointly developing the 3 GW hybrid project Bornholm Energy Island.

Based on the guidelines of the MSP, the Site Development Plan makes determinations for OWFs and grid connection. The latest version was released in January 2023. Due to the dynamic developments in Germany regarding the offshore wind targets, the next Site Development plan is already in preparation.

The following Figure 5 shows the map for the Baltic Sea from the 2023 Site Development plan. It displays the OWFs in the German Baltic Sea and the corresponding cable routes.

The size of internal waters (to the baseline) and territorial sea (12-nm zone from the baseline) in the German Baltic Sea totals approximately 10,900 km². The EEZ in the Baltic Sea measures about 4,500 km².

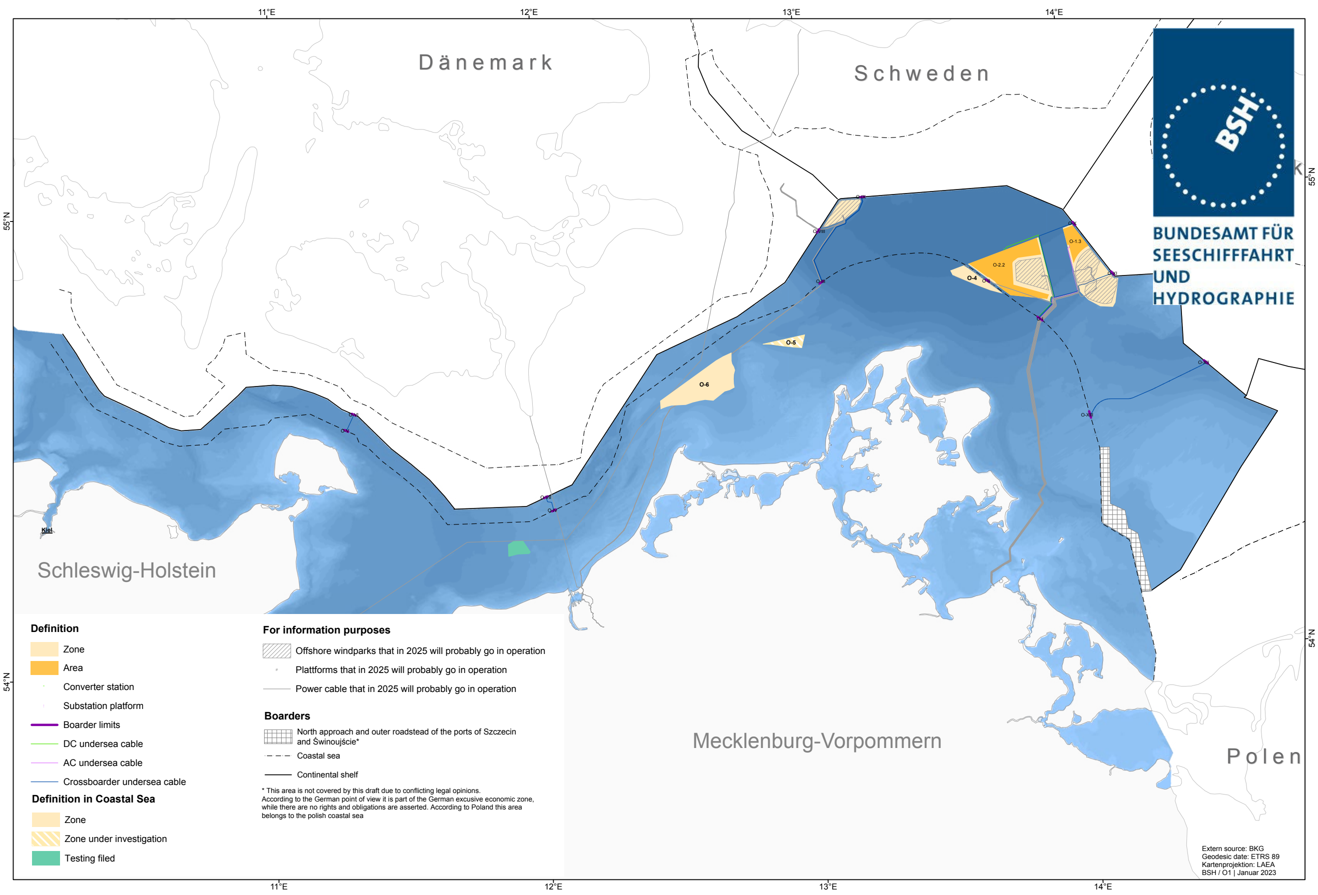

Figure 5 – Potential German windfarm areas. **(BSH-Homepage)**

Offshore wind in Latvia

Currently there is no one operating offshore wind park in Latvia and the installed offshore wind capacity is 0 MW. There is huge interest from private developers to construct offshore wind parks in the offshore sites defined in Maritime Spatial Planning (MSP) of Latvia, but the existing legislation doesn't allow to issue the license for offshore wind development and the Ministry of Climate and Energy in Latvia, responsible for the permits process of offshore wind, is planning to issue the licenses through auction procedure. It is planned to issue the offshore wind license in 2025 – 2026. According to the RES target values set in Latvian National Energy and Climate plan the size of sites in terms of capacity of offshore wind could exceed 3 GW. The estimated offshore wind potential in Latvia is much higher and could reach 15 GW. Right now, the Latvian MSP is going on revision where the potential offshore wind sites could be expanded and some new sites in offshore allocated.

The main goal of expansion and new areas is to increase RES production and especially offshore wind generation, what has huge potential. For offshore wind energy exchange/export among countries of BEMIP region Latvian TSO is developing the few potential new hybrid interconnections to Estonia, via 4th EE-LV interconnection (ELWIND), to Germany/Estonia, via connection to EE and DE (Baltic WindConnector) as well as to Sweden, via potential interconnector to Sweden (LaSGo link). All of the projects are with a main goal to connect high-capacity offshore wind parks around Baltic Sea and improve the system security and stability of the system, taking into account huge amount of connected RES, as well as system connectivity providing sufficient market integration. Currently the projects go through overall assessment of need of project in long term perspective to be in line with the identification of system needs (IoSN). The projects will be assessed according to costs and benefit analysis performed by TSO in detailed studies.

The LaSGo link project has been promoted by Latvian TSO only and it is in very early stage of development. The project is under consideration and currently in study phase from Latvian TSO. AST, as Latvian TSO is alone preparing technical and economical study to identify future project benefits and development perspectives. When finalized, the study will be shared with and bilaterally discussed further between Latvia and Sweden, and with Swedish TSO, Svenska kraftnät, as there will be need for larger reinforcement of on-shore transmission network on Swedish side. From Latvian TSO point of view the project is going to contribute to the EU 2050 long-term strategy, where the EU aims to be climate-neutral by 2050 – an economy with net-zero greenhouse gas emissions. Latvian TSO is looking further to develop and study submarine HVDC transmission hybrid project to connect the power systems of Latvia and Sweden for the secure and stable operation. Due to high potential of off-shore and on-shore wind farms development in the Baltic Sea Western shore of Latvia and huge potential of off-shore wind development around Gotland island of Sweden, the LaSGo project could be realized in hybrid solution. This will meet the current challenge of security of supply experienced in this region, especially after Baltic States desynchronization from IPS/UPS (Russia and Belarus power system) and synchronization with continental Europe in 2025.

All of the potential hybrid interconnectors mentioned above are under development and further, much more detailed studies must be performed. See potential Latvian windfarm areas in the Figure 6.

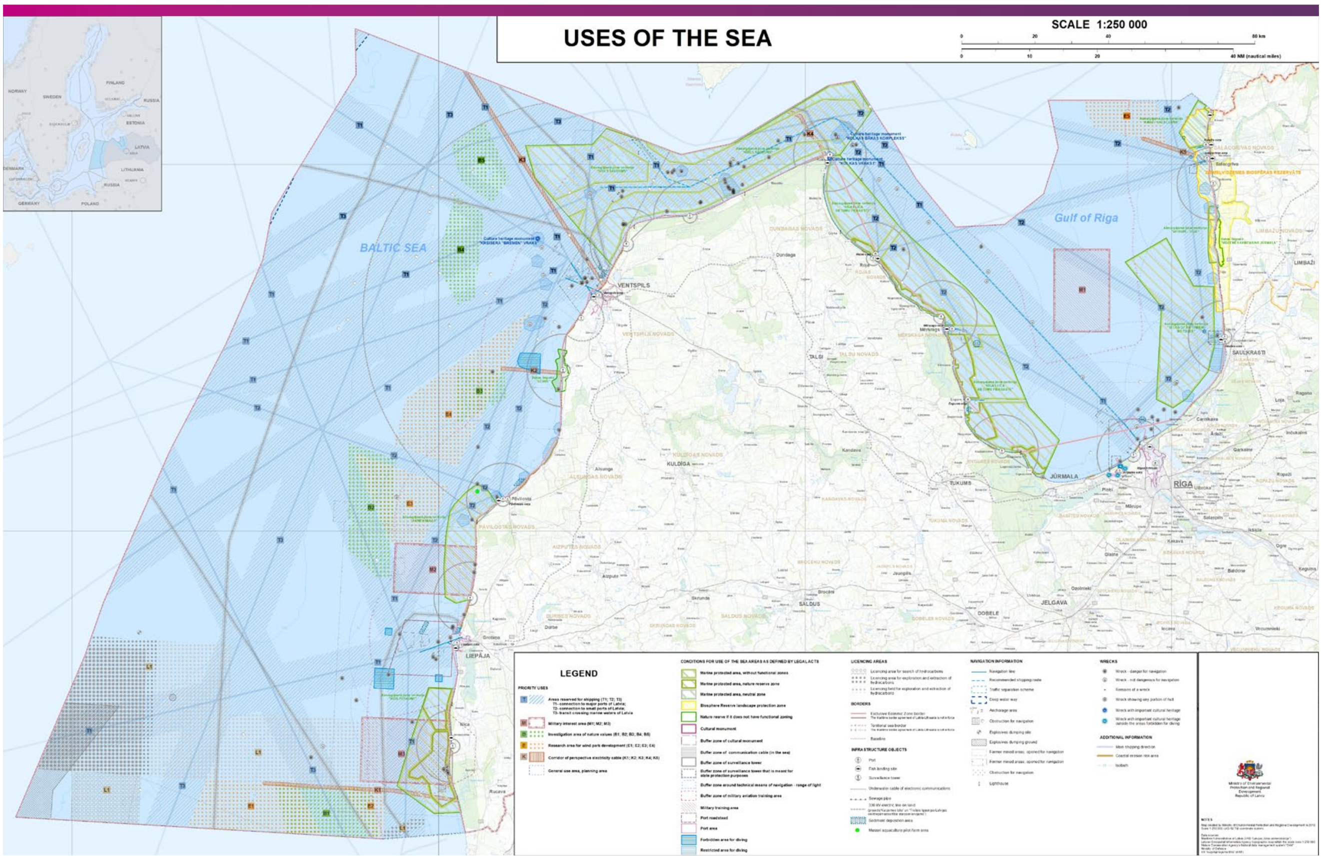

Figure 6 – Potential Latvian windfarm areas.

Offshore wind in Lithuania

MSPs identified three possible territories for offshore RES development. However, two of these territories have been postponed from detailed investigation due to the close coastal area (influence to military equipment) and deep waters sea area, which are not efficient for primarily offshore development.

The biggest dedicated maritime territory has been chosen for further investigation and development of the first two offshore wind parks.

Currently, no offshore wind capacity is installed in the Lithuanian power system. By 2030, two parks (1400 MW total installed capacity) are expected to be in operation. The first offshore wind park (700 MW) will be located about 36 km from the shore and the second one – about 30 km. Both parks will be connected by radial connection to Lithuanian power system.

The EEZ of the Republic of Lithuania in the BEMIP is approx. 4,564 km². The area of the territory planned for the offshore wind park (Phase I – for the 30 March tender) in the Baltic Sea is approximately 120 km².

The area of the territory planned for the offshore wind park (Phase II – for the autumn tender) in the Baltic Sea is approximately 136,39 km², both shown in Figure 7.

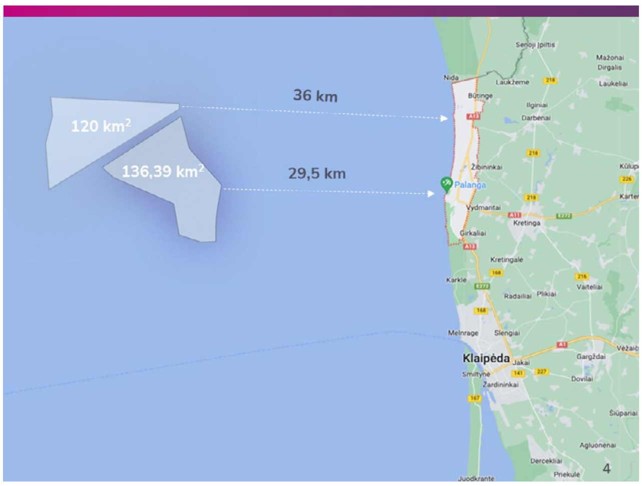

Figure 7 – Potential Lithuanian windfarm areas. **(Apie projektą – OffshoreWind.lt)**

Offshore wind in Poland

In Poland, OWFs may only be located in the Polish EEZ. This means a minimum distance from the shoreline of 12 nautical miles (approx. 22 km from the shore), which significantly reduces the negative impact on the landscape of coastal tourist destinations. The projects are also located outside the most important areas for domestic fisheries.

On 14 April, 2021, the Council of Ministers adopted the Spatial Development Plan for Polish Maritime Areas. The plan designates areas dedicated to renewable energy, where it is possible to build OWFs; this area is 2,340 km² (10 % of the EEZ).

Offshore wind farm projects will be developed in the Polish EEZ of the Baltic Sea in the area designated in the maritime development plan in the area of the Słupsk Bank, the Central Bank and the Oder Bank, where areas with renewable energy function are allowed in the plan. In Figure 8, these are grey areas marked 14E (the Oder Bank), 43E, 44E, 45E and 46E on the Słupsk Bank and to the north of them area 60E on the Central Bank.

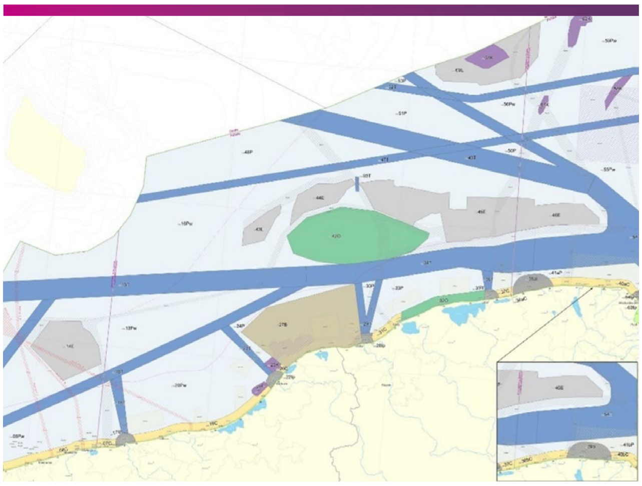

Figure 8 – Potential Polish windfarm areas.

The Energy Policy of Poland assumed development plans for OWFs in Polish EEZ in two phases: first reaching 5.9 GW and up to 11 GW in total.[11]

Offshore wind in Sweden

Sweden today has some 200 MW of offshore wind in operation, most of which was installed between 2000 and 2013. There is one fully consented 640 MW wind farm, Kriegers Flak, in the Swedish EEZ in southwestern part of the Baltic proper. If a final investment decision is made by the project developer, Swedish Kriegers Flak is expected to be commissioned in 2029. An additional eight offshore wind projects located in the Swedish EEZ of a combined capacity of some 14 GW have applied for permits between the years 2021–23. Final decisions from the national government on these permits are expected in 2024–25. Significant onshore reinforcements are required to connect the majority of these projects, hence, if permitted, most of these projects can come online in 2033 at the earliest.

Sweden adopted its first MSPs in February 2022. The current plans hold designated areas that can produce between 20–30 TWh of electricity per year. Directly after the first version of the Swedish MSPs were published, the government commissioned the Swedish Energy Agency and the Marine Spatial Planning with the task of reviewing the new plan and identifying supplementary offshore areas that allow for an additional 90 TWh per year. The new national ambition is thus that the revised Swedish national MSP will allow for up to 120 TWh of offshore electrical generation per year, corresponding to a combined capacity of some 29–33 GW. It is, however, important to note that the national MSP is a non-binding guiding document only, i. e. final permitting is decided on a project-by-project basis. Figure 9 presents the potential wind farm projects in Sweden.

11 Portal Gov.pl (www.gov.pl)

Figure 9 – Potential Swedish windfarm areas. **(Blekinge | Länsstyrelsen Blekinge [lansstyrelsen.se])**

4 Potential Environmental Impacts – specific to BEMIP Offshore Grids

An environmental and ecological impact results from the installation of OWFs and related infrastructure. Therefore, the development of wind farms may cause societal disagreements of opinion. Nevertheless, by offering a clean and dependable source of power, OWFs are essential in the fight against global warming. They contribute to a decrease in the use of fossil fuels and the production of renewable energy, hence reducing the effects of global warming and its related ecological effects.

The Baltic Sea

The Baltic Sea, which has a total size of 377,000 square kilometres and an average depth of 52 meters, is one of the world's largest inland seas. The Baltic Sea has a low salinity (8–10 %). The Baltic Sea receives freshwater from several rivers, but only through the straits of Denmark, which are shallow and narrow, the Baltic Sea can exchange water with the ocean to receive saltwater.

The ecosystem's characteristics, including, for example, species composition, are significantly influenced by the water temperature and salinity in the area. Due to the complicated topography, high horizontal and vertical gradients, and significant atmospheric fluctuation across a range of time scales, the temperature and salinity fields of the Baltic Sea exhibit significant temporal and spatial variability. Compared to the brackish water of the Baltic Sea, inflowing water from the Danish straits is saltier and heavier, which causes it to sink to the deep layers. The Gotland Deep, one of the deepest basins, has the greatest salinity-containing body of water in the Baltic Sea. At a depth of 40 to 80 meters, the salinity of the Baltic Sea increases rapidly before levelling off again in the deeper layers. The halocline, which divides the deep water layers from the surface water and prevents oxygen from moving from the surface layer to the deep water, is the layer where the salinity rises noticeably.

Ecological impact

Disturbing marine environments is one of the main ecological effects of OWFs and grid infrastructure. Offshore RES installation and operation may produce underwater noise, vibrations and electromagnetic fields that may interfere with marine animals' behavior and migration patterns. Sensitive species can be either temporarily or permanently relocated as a result of this disturbance, which may have an impact on their ability to obtain food or reproduce. Bird and bat species may be at risk from OWFs, especially during migration routes. It is possible for bats and birds to get killed if they run into the turbine blades.

Extensive seabed trenching may be necessary for the construction of transmission lines to connect OWFs to the grid, which might further disturb marine habitats. The procedure may result in sediment dispersion, harming creatures that live on the sea floor and resulting in a loss of certain habitats. Water flow patterns may change, and silt may be resuspended during the construction of offshore wind facilities. These modifications may impact the make-up of the seafloor, harming bottom habitats and upsetting the delicate balance of aquatic ecosystems. As a result, there may be an influence on marine biodiversity and species population.

An environmental impact assessment (EIA) is required from offshore wind parks to map out the environmental effects and find a balance between energy requirements and environmental conservation. For offshore grid infrastructure, a similar approach is being performed. The Baltic Sea's ecological stability and biological richness are also greatly protected under Natura 2000. The Natura network may prohibit offshore energy generation in the area.[12]

Impacted areas

A main impact area of offshore wind power is the generation area and the area of the cable routes, but offshore wind generation also affects mainland areas as, most likely, reinforcement to the onshore grid, at least the connection line, needs to be built. Even though offshore wind parks would be situated far from the coast, the Baltic Sea's shorelines and coastal zones may be affected, particularly while infrastructure is being built. Recreational activities and coastal scenery may alter as a result.

Ecologically positive effects

Offshore wind also has a number of potential ecologically positive effects. As bottom trawling is not possible within offshore wind parks, fish stocks can recover. Furthermore, installing underwater elements such as foundations is a necessary part of building OWFs. Diverse marine creatures may adhere to submerged constructions, which can serve as artificial reefs. These buildings have the potential to create new habitats, increase local biodiversity, and serve as safe houses for many species throughout time. [13]

Conclusion

As a renewable energy source, offshore wind has a lot to offer. To reduce possible harm to coastal and marine ecosystems and animals while simultaneously maximising the chance to have a beneficial ecological impact, careful site selection, rigorous environmental studies, and ongoing monitoring are crucial. The key to securing a sustainable future for both people and the natural world is striking a balance between energy requirements and environmental conservation.

12 Natura 2000 | Environment | European Commission (europa.eu)
13 Baltic-LINes-2030-and-2050-Baltic-Sea-Energy-Scenarios.pdf (vasab.org)

5 Spatial Planning Needs – specific to BEMIP offshore grids

There are many aspects to consider when developing, building and operating offshore RES and related infrastructure. Disagreements between different maritime uses, such as with fishing, shipping, nature protection, tourism, and military usage, result from the expansion of wind farms. Generally, the number of conflicts is, however, lower compared to onshore wind farm projects.

A sustained and peaceful cohabitation of offshore wind energy with other maritime activities depends on finding solutions that consider the requirements of other parties. The assistance and participation in research and planning of all the involved parties are required to identify the ideal locations for the construction of OWFs. Information about the Baltic Sea basin´s country specific MSP can be found in the Appendix.

Nature protection

A brief overview of the environmental impacts in the BEMIP region related to the offshore wind energy is given in Chapter 5.

Fishing

For the coastal Baltic nations, fishing is a significant source of income. The major concern among fishermen is that OWFs will reduce fishing opportunities and fish catches. Coexistence between offshore wind parks and fishing grounds is possible through careful planning, ongoing dialogue and the implementation of mitigation measures. To find acceptable locations for OWFs that have minimal effects on fishing grounds, wind park developers have to work with fishing communities all over the planning process.

Shipping

The shipping traffic in the Baltic Sea is the most intensive from the Gulf of Finland until the Kattegat in the Danish waters and has a lower intensity in the Gulf of Bothnia. OWFs require considerable maritime space, and their location might alter shipping routes. One of the distinctive features of the Baltic Sea is the ice cover that at least the northern parts of the sea get every winter. Offshore wind parks are seen as especially challenging from the wintertime traffic's perspective as they cause new restrictions to already challenging circumstances. To mitigate possible effects, site locations need to be carefully considered.

Offshore energy may open up new business prospects for the maritime sector, too. Wind farm and network installation, maintenance, and repair vessels are in great demand. Companies and income streams for shipping businesses that adapt their offerings to serve the offshore wind sector can expand. Collaboration between the maritime industry and the renewable energy sector can be generated through OWFs. The collaboration may result in advancements in vessel technology and design, such as fuel-efficient or wind park-specific boats. In addition, it may encourage the creation of fresh logistical and marine support systems for the offshore wind sector.

Tourism

Even if the majority of offshore wind energy development is occurring in places farther from the coast, disagreements may still occur if wind farms are situated in areas that are used, for example water sports or are visible from the coast. In many of the BEMIP area's member nations, maritime and coastal tourism is a significant economic sector. This industry should be involved in planning procedures at the regional and local levels. It is important to gather information on the coastal tourism and leisure industry so that planning initiatives may take local demands into account. Access to offshore wind farms for recreational vessels should be allowed wherever possible. Wind farms may even operate as tourist attractions, and visitor centres can have added educational value.

Military

Offshore wind parks include wind turbines as well as related infrastructure, such as assistance boats and undersea cables. Due to their ability to influence shipping lanes and marine operations, these sites may require extra care during military actions. To guarantee safe and effective mobility, the military would need to take the location and design of wind parks into account while organising exercises, patrols or other naval activities. Communication signals and radar systems may be impacted by wind turbines. Radar system performance may be impacted by radar reflections and signal clutter caused by wind turbine revolving blades. Radar operations may need to be adjusted as a result of this interference, which might also affect military surveillance capabilities. In the proximity of wind parks, radio and satellite communications may also be impacted, needing mitigation measures or other communication techniques.[14] OWFs are important pieces of infrastructure that need to be protected from possible dangers such as physical attacks or sabotage. In times of increased security concerns, the military may be involved in securing and protecting these sites. To guarantee the preservation of the wind parks, this may include stepped-up patrols, monitoring or collaboration with appropriate authorities.

Conclusion

Many different parties must work together, conduct research and prepare for the integration of OWFs. A sustained and peaceful cohabitation of offshore wind energy with other maritime activities depends on finding solutions that consider the requirements of fishing, shipping, tourism, the environment, the military and other parties. While conserving the essential functions of our seas, a balanced strategy that promotes collaboration and shared vision can help create a cleaner, more resilient energy future. The establishment of a coherent spatial vision for the network is crucial at the regional level.

14 Defence and other uses | The European Maritime Spatial Planning Platform (europa.eu)

6 High-Level Results on Offshore Network Infrastructure Needs

This chapter provides an overview of the goals for 2030, 2040 and 2050 and possible grid expansions based on modelling results for 2040 and 2050. An overview of how the modelling was done can be found in the "Methodology Document".

By 2040, 13 different options for creating cross borders connections in the Baltic Sea will have been investigated as viable candidates. Two potential transmission corridors were found in the modelling results. The 2050 modelling, however, took into account 67 possible choices for additional candidates, nine of which have been selected as viable transmission corridors connecting offshore RES through hybrid infrastructure. The findings indicate that there is a potential in BEMIP to develop some offshore hybrid projects linking offshore RES to shore and countries with each other.

The realisation of a more meshed offshore network through hybrid infrastructure will increase the amount of energy integrated into the onshore electricity system. Generally, it seems that only a few offshore hybrid connections will materialise in BEMIP in 2030, but radial connections will be a start. With expanded capacities, there will be a need for more hybrid connections in 2040, and by 2050, a significant rise in infrastructure needs may already be noticed.

In the next chapters, the figures are for illustrative purposes and do not represent the actual locations of the generation capacities.

6.1 2030 Potential Offshore Network Infrastructure Needs

In line with the EU decarbonisation targets, the EU countries are starting to assess and to develop a possible future offshore grid in the BEMIP region. This is a first iteration and starting point for the offshore grid, connecting the locations where some high-capacity offshore wind parks are already announced and planned to be in operation by 2030 and beyond. In addition, the world's first hybrid offshore interconnector Krieger's Flak Combined Grid Solution (see more in Chapter 4) is already operating in the Baltic Sea. In the 2030 time horizon, most of the foreseen capacities are radially connected to the onshore systems of the respective countries. The TSOs keep the opportunity to optimise and expand these connections for higher meshed grid solutions in offshore which will become much more relevant after 2030 when offshore wind generation capacities and consumption related to hydrogen production will rise.

As seen in Chapter 3, the BEMIP offshore grids are anticipated to have 27 GW of offshore wind capacity added by 2030. When comparing these goals to the current 3 GW installations, it implies that within the next six years, the amount of offshore energy produced will increase by a factor of seven. To further translate this, installations of 3 GW per year are required between 2024 and 2030 in the BEMIP offshore grids region.

Figure 10 depicts the starting situation for 2030, where with the light green means existing and planned hybrid connections and dark green means radial connections. No expansion loop is performed for the 2030 time horizon.

In Figure 11, it is possible to see the offshore generation growth in the BEMIP offshore grids region by the years 2030, 2040 and 2050. In Figure 11, green depicts MS targets and the orange line depicts TSO data, including Latvian and Sweden targets.

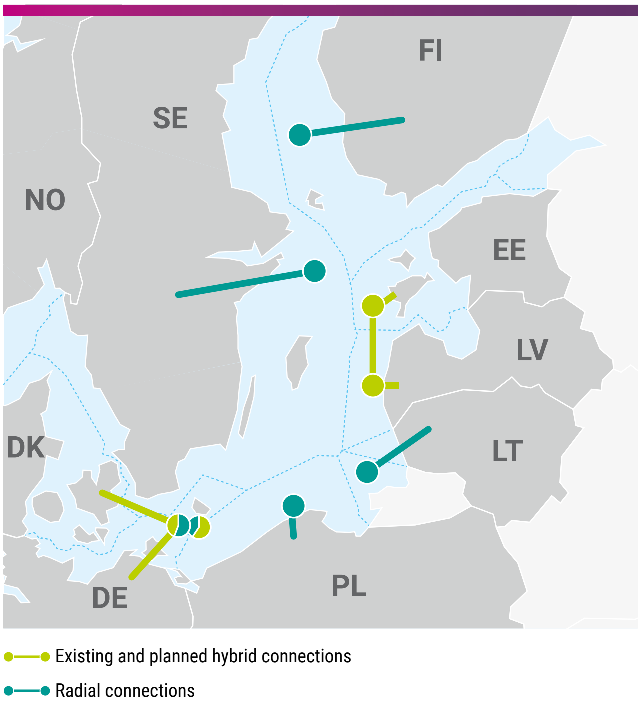

Figure 10 – Starting situation in 2030.

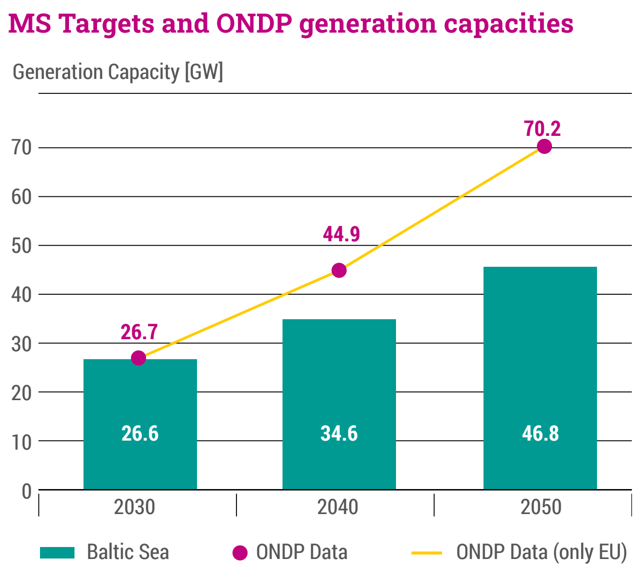

Figure 11 – Offshore generation targets in the BEMIP offshore grids region for the years 2030, 2040 and 2050.

6.2 2040 Potential Offshore Network Infrastructure Needs

In 2040, most OWFs will still be connected radially, but new cross-border hybrid connections could be integrated into the grid. Depending on the scenario of whether a configuration with or without DC circuit breaker was assumed (see the "Methodology document"), up to two additional links have been identified with a total capacity of 3 GW and a total route length of 875 km. The identified offshore transmission corridors, which are shown in pink in Figure 12, leading in the direction from north-east to south-west. The starting situation in 2040 has a 45 GW overall offshore transmission capacity, made up of 33 GW radial corridors, 5 GW hybrid corridors and 7 GW potential hybrid corridors. An expansion loop has been carried out on top of this starting situation for the 2040 time horizon. Figure 12 depicts potential transmission corridors with radial connection in 2040, whereby the light green means existing and planned hybrid connections, dark green means radial connections and pink depicts ONDP expanded hybrid connections.

Table 3 summarises the key numbers related to these expansions, including the radial connections.

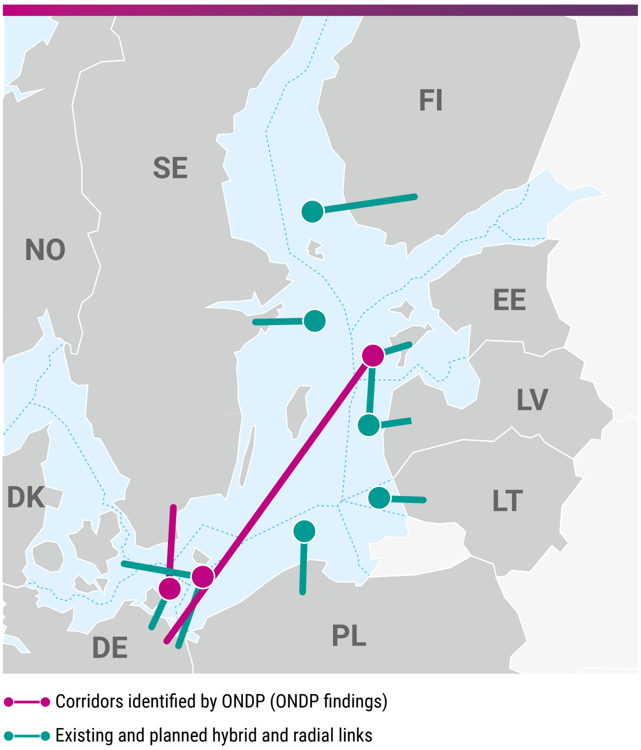

Figure 12 – Potential transmission corridors in the BEMIP offshore grids corridor in 2040.

2040	
Number of expansions selected	2
Total transmission capacity of expansions selected	3 GW
Additional radial connections in 2040 (compared to 2030)	15
Total number of generation capacity in 2040	44.9 GW

Table 3 – The key numbers for 2040.

6.3 2050 Potential Offshore Network Infrastructure Needs

Several starting situations for 2050 have been evaluated based on anticipated technological advancements (with/ without/ with later availability of DC breakers). For a more thorough explanation, please refer to the methodology document.

The results for the target year 2050 indicate very high capacities of offshore wind in the Baltic Sea and the whole BEMIP region. Offshore wind capacity is a starting assumption and was not calculated by the optimiser. The installed capacities of offshore wind will increase significantly from 27 GW in 2030 to 70 GW in 2050. In 2050, the network will take shape and there will be more hybrid connections between different countries, and the potential length of hybrid connections will increase. The identified offshore transmission corridors are leading in the direction from north-east to south-west and from east to west. Depending on the scenario, up to nine transmission corridors with a total transmission capacity of 10.6 GW were selected. They are shown in pink in Figure 13. This would add 2408.5 km of additional infrastructure to the grid in 2050. Figure 13 depicts potential transmission corridors with a radial connection in 2050, where again the light green means existing and planned hybrid corridors, dark green means radial connections and pink depicts ONDP expanded hybrid connections.

Table 4 summarises the key numbers related to these expansions, including the radial connections.

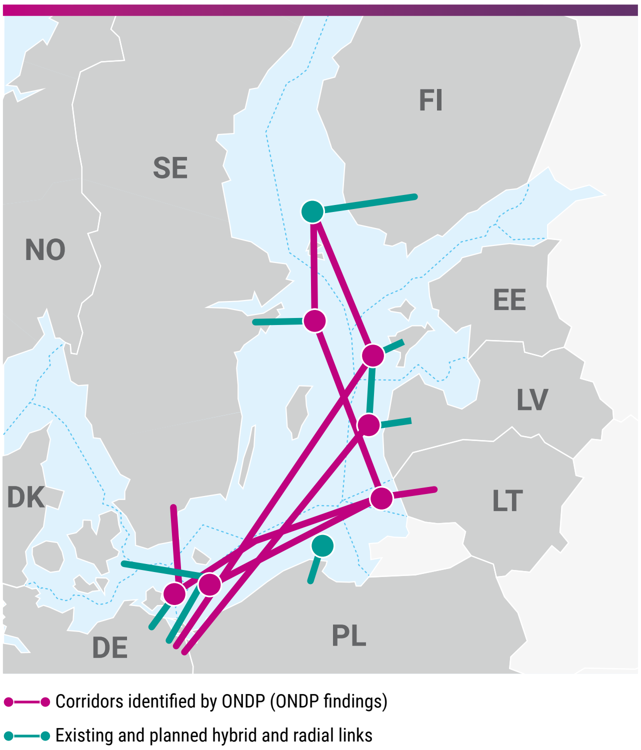

Figure 13 – Potential transmission corridors in the BEMIP offshore grids corridor in 2050.

2050	
Number of expansions selected	9
Total transmission capacity of expansions selected	10.6 GW
Additional radial connections in 2050 (compared to 2040)	6
Total number of generation capacity in 2050	70.2 GW

Table 4 – The key numbers for 2050.

6.4 Resulting assets for the offshore electrical infrastructure

In the tables below the equipment needs, route length and costs for configuration with and without DC circuit breaker are shown, which also take radial connections into account. Onshore grid reinforcements behind the onshore connection points are not considered.

Equipment Needs Route Length, Number	Radial (route length)			Expansion		Radial – considered in the expansion loop			Total			Total Sum [km] or nr.
Configuration with DC circuit breaker [km], [Nr]	2025 – 2030	2031 – 2040	2041 – 2050	2031 – 2040	2041 – 2050	2025 – 2030	2031 – 2040	2041 – 2050	2020 – 2030	2031 – 2040	2041 – 2050	2025 till 2050
Onshore DC Cables (updated)	895	1,696	271	20	26	1,138	555	1,910	2,033	3,259	4,954	10,246
Offshore DC Cables (updated)				989	2,747							
Onshore AC Cables (updated)	576	252	372						576	252	372	1,200
Offshore AC Cables (updated)												
Offshore DC converters	9	12	2			9	3	12	18	15	14	47
Onshore DC converters	9	12	2	2	5	9	3	12	18	17	19	54
Offshore AC substation	9	3	3						9	3	3	15
Offshore node expansion (incl. DC breaker)				2	9				0	2	9	11
											Total Route Length	**11,446**

Table 5 – Equipment needs – route length, configuration with DC circuit breaker.

Costs	Radials			Expansion		Radial – considered in the expansion loop			Total			Total Sum [M€]
Configuration with DC circuit breaker [M€]	2025 – 2030	2031 – 2040	2041 – 2050	2031 – 2040	2041 – 2050	2025 – 2030	2031 – 2040	2041 – 2050	2020 – 2030	2031 – 2040	2041 – 2050	2025 till 2050
Onshore DC Cables (updated)	1,399	3,294	696	44	76				3,561	8,341	12,492	
Offshore DC Cables (updated)				3,005	6,158	2,162	1,999	5,562				24,394
Onshore AC Cables (updated)	384	442	1,013						384	442	1,013	
Offshore AC Cables (updated)												1,839
Offshore DC converters	5,035	8,171	1,650			5,280	3,960	11,313	10,315	12,131	12,963	35,409
Onshore DC converters	2,289	3,714	750	750	1,425	2,400	1,800	5,142	4,689	6,264	7,317	18,270
Offshore node expansion (incl. DC Breaker) E20				495	2,558				0	495	2,558	3,053
Offshore AC substation	1,891	1,720	2,955						1,891	1,720	2,955	6,566
												89,529

Table 6 – Equipment needs – costs, configuration with DC circuit breaker.

Equipment Needs Route Length, Number	Radial (route length)			Expansion		Radial – considered in the expansion loop			Total			Total Sum [km] or nr.
Configuration without DC circuit breaker [km], [Nr]	2025 – 2030	2031 – 2040	2041 – 2050	2031 – 2040	2041 – 2050	2025 – 2030	2031 – 2040	2041 – 2050	2020 – 2030	2031 – 2040	2041 – 2050	2025 till 2050
Onshore DC Cables (updated)	895	1,696	271	0	7	1,138	555	1,910	2,033			7,370
Offshore DC Cables (updated)				0	898					2,251	3,086	
Onshore AC Cables (updated)	576	252	372						576	252	372	1,200
Offshore AC Cables (updated)												
Offshore DC converters	9	12	2			9	3	12	18	15	14	47
Onshore DC converters	9	12	2	0	2	9	3	12	18	15	16	49
Offshore AC substation	9	3	3	0	2				9	3	5	17
Offshore node expansion (with converter), E18	0	0	0	0	2				0	0	2	2
											Total Route Length	**8,569**

Table 7 – Equipment needs – route length, configuration without DC circuit breaker.

Costs	Radials			Expansion		Radial – considered in the expansion loop			Total			Total Sum [M€]
Configuration without DC circuit breaker [M€]	2025 – 2030	2031 – 2040	2041 – 2050	2031 – 2040	2041 – 2050	2025 – 2030	2031 – 2040	2041 – 2050	2020 – 2030	2031 – 2040	2041 – 2050	2025 till 2050
Onshore DC Cables (updated)	1,399	3,294	696	0	22				3,561			
Offshore DC Cables (updated)				0	2,551	2,162	1,999	5,562		5,293	8,831	17,684
Onshore AC Cables (updated)	384	442	1,013						384	442	1,013	
Offshore AC Cables (updated)												1,839
Offshore DC converters E18	5,035	8,171	1,650			5,280	3,960	11,313	10,315	12,131	12,963	35,409
Onshore DC converters	2,289	3,714	750	0	675	2,400	1,800	5,142	4,689	5,514	6,567	16,770
Offshore node expansion (with converter), E18	–	–	–	0	1,485				0	0	1,485	1,485
Offshore AC substation	1,891	1,720	2,955	0	1,191				1,891	1,720	4,145	7,757
												80,943

Table 8 – Equipment needs – costs, configuration without DC circuit breaker.

7 Reflections for the Region

Regional key-messages and reflection on the results

The present offshore development plan is the first step in identifying connections and the potential needs of offshore network expansion. Due to the early stage of development of the offshore infrastructure and multiplicity of factors (technical and economical) impacting the realisation of the assets, the first offshore development plan provides a strategic framework for the deployment of the BEMIP offshore network.

Reflections on the offshore network infrastructure needs for 2030

In the first ONDP iteration, the BEMIP TSOs are indicating and highlighting the potential offshore wind energy which should be transferred to the mainland at present best estimated consumption centres. The costs of offshore network are high compared to the onshore network, but currently they are not assessed in more detail because the TSOs could expect that in the future, some technological progress is expected. The main goal and benefit of common ONDP in BEMIP is to integrate all recognised offshore wind potential for each country as well as to identify and plan possible future connections to increase the integration of offshore RES.

Reflections on the offshore network infrastructure needs for 2040

In the decade from 2030 to 2040, the Baltic offshore transmission network will evolve into a mix of radial connections, classical interconnections and offshore hybrid network solutions connecting the offshore RES capacities deployed in the basin's waters. It is important to mention that the offshore network infrastructure will play a much more crucial role in the entire power system. TSOs will develop more offshore hybrid connections than in the previous decade, with the opportunity to connect two or more offshore hubs, countries, and bidding zones. Going ahead with the European Fit for 55 targets, EU MSs will develop high-capacity offshore generation nodes, and capacity should be transferred to the main consumption centres and also potential new demand locations for hydrogen production.

After 2040, the offshore network will become more meshed with different hybrid AC and DC solutions, which will enable offshore wind development as well as power exchange among EU MSs. The potential increase of demand for hydrogen production will require more flexible sharing of RES as well as new high-capacity offshore wind generation. TSOs of the BEMIP region expect that more hybrid solutions will come into operation; the technology will become cheaper as such and much more available for different offshore connection solutions. TSOs will improve offshore network infrastructure with long HVDC connectors between offshore hubs, more than two countries or bidding zones. TSOs of the BEMIP region will develop and expand the offshore network in parallel with the onshore network to enable the transfer of offshore wind energy to the consumption places.

Reflections on the offshore network infrastructure needs for 2050

Due to very high ambitions in the EU to develop the potential of offshore wind for each member state, TSOs will closely cooperate to develop a more meshed AC and DC offshore network to utilise the full potential of offshore wind and reduce offshore wind curtailment. TSOs of the BEMIP region will improve the offshore network infrastructure according to the needs triggered by generation developments. In future, the offshore transmission network will be more meshed. TSOs are expecting that new technologies will evolve which can provide stable multiterminal HVDC functioning as well as allow the integration of AC and DC connections in an efficient manner.

In the long term, a very high amount of electricity will be produced offshore; therefore, it is very important to strengthen a cross-border cooperation and power exchange among BEMIP region countries. It is expected to implement new multiterminal solutions in HVDC technology which allow more HVDC-links to be connected together through one hub or substation. The main challenge for TSOs still remains how to transfer very huge offshore generation (3 – 5 GW) from production nodes offshore to main consumption centres and deficit areas connected to the onshore network. Looking towards 2050, the TSOs of the BEMIP region plan in parallel to introduce onshore network reinforcements and new cross-border interconnectors in order to prepare secure, robust and sustainable power system of the BEMIP region.

Reflections on hydrogen infrastructure needs

In the BEMIP region, the potential capacity of offshore wind that was analysed within the ONDP studies reaches up to 70 GW. The main challenge will be to provide sufficient network infrastructure and also to meet the consumption in every hour. The production output from wind power plants can vary greatly from hour to hour and it will lead to situations when in some periods there is insufficient transmission capacities or enough consumption. The ONDPs find that the RES capacities installed in the different timeframes and the foreseen wind profiles offer large opportunities for the development of hydrogen transmission and storage infrastructure that could be a part of a solution to utilise the offshore wind energy most efficiently and support the decarbonisation of other sectors. The hydrogen infrastructure developments considered are H_2 electrolyzers and the hydrogen transport corridors, which could allow the utilisation of energy produced through wind energy.

The ongoing hydrogen storage and transmission plans by BEMIP region gas TSOs can be viewed on a level of BEMPI by the EC[15]. The public information about different initiatives of hydrogen developments is available on the EC website.[16] Figure 14 depicts possible future hydrogen infrastructure in the BEMIP region.

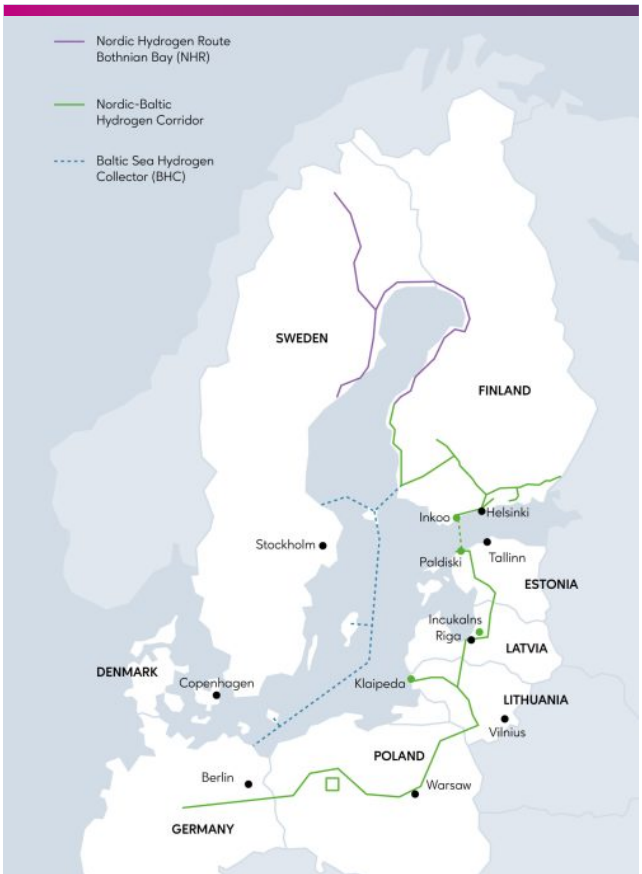

Figure 14 – **Possible future H_2 infrastructure projects in the BEMIP offshore grids corridor.**

15 https://energy.ec.europa.eu/topics/infrastructure/high-level-groups/baltic-energy-market-interconnection-plan_en
16 Circabc (europa.eu)

8 BEMIP Infrastructure Projects

The planned projects for the BEMIP offshore grids are discussed in more detail in this chapter.

Estonian Latvian 4th connection

In addition to the MoU for the advancement of wind energy that Estonia and Latvia signed in 2020, Elering (Estonian TSO) and AST (Latvian TSO), the two countries' major grid companies, in the spring of 2021 signed a contract under which the best possible solutions for the construction of an additional 700–1,000 MW of transmission capacity will be jointly examined. The plan calls for building a fourth 330 kV connection between Estonia and Latvia, which would enable the installation of OWFs.

In 2021–2022, Elering carried out a preliminary analysis of the possible route corridors of the Estonian-Latvian 4th transmission line, as a result of which the most suitable start in Estonia is from the west coast of Estonia to the west coast of Latvia (Pāvilosta region). Building a new 330 kV network across Muhu and Saaremaa starting in the Lihula region is required (see Figure 15 below). The route corridor and precise technical solution for the fourth transmission line between Estonia and Latvia are still to be determined because they depend on environmental impact analysis and planning. The programme for environmental impact assessments is expected to be prepared in 2024 and implemented between 2025 and 2027. For 2025–2026, designing is likely to be planned. The full project will be finished in 2030+.

Figure 15 – Planned EE-LV fourth connection route.

EstLink 3

The Estonian and Finnish electricity system managers Elering and Fingrid signed an MoU in June 2022, agreeing to begin the collaboration process for the construction of the third Estonian – Finnish electricity connection (EstLink 3) (see Figure 16). Technical concerns, required expenditures and a suitable timeframe are all listed as shared tasks in the agreement. EstLink3 will be the traditional transmission link as no offshore generation is currently planned near the route (due to the military reasons). EstLink 3 will have a proposed direct current connection capacity of 700 MW at either a 450 kV or 320 kV nominal voltage. Possibly in 2035, the new connection will be finished. EstLink3 consists of converter stations at both ends and of an HVDC cable line that connects Estonia and Finland.[17]

Figure 16 – Planned EstLink3 cable route.

Baltic WindConnector

Referred to as the "Baltic WindConnector (BWC)", the aim of the project is to integrate offshore wind with an installed capacity of 2 GW from Estonia and Latvia to the Baltic countries and Germany via a 525 kV HVDC connection. The project provides additional cross-border trading capacity between the Baltic States and Germany and hence contributes to the integration of Baltic States into the common EU wholesale electricity market. With BWC, security of supply is increased in all three countries and the even larger Baltic Sea region. This will be further investigated throughout the project development.

Originally planned as a point-to-point hybrid connection between Estonia and Germany, Elering (EE), 50Hertz (DE) and AST (LV) are currently assessing a potential widening of the project scope and topological setup. Hence, the interconnector will enable Estonia and Latvia to become an exporter of green electricity to the European electricity market whilst enabling Germany and continental Europe to diversify its green electricity supply as it aims to achieve climate neutrality by 2045.

Harmony Link

After the synchronisation of electricity systems of the Baltic countries with the Continental European Synchronous Area, commercial electricity trade will be ensured by the new interconnection between the Lithuanian and Polish power systems, Harmony Link. A 700 MW link will be Poland and Lithuania's second electrical link; the LitPol Link has been in service since 2016.[18]

17 EstLink3
18 Harmony Link

Bornholm Energy Island

Together, 50Hertz and Energinet are joint partners in the development of a power hub on the island of Bornholm that is able to provide electricity to consumers in either country, depending on the market and demand in Germany, Denmark and Europe more widely. This innovative and visionary project represents a change from the previous philosophy of building isolated OWFs with a power connection to one country only.

Electricity generated by the wind farms located off the coast of the island will be centralised at this hub and then converted into HVDC and transported via 525 kV HVDC sea and land cable systems to onshore substations in Zealand (in Denmark) and Mecklenburg-Western Pomerania (in Germany). The power cables have a dual purpose as they can also be used to connect the electricity markets of the various countries.[19]

The Bornholm Energy Island consists of assets at sea and on land. Submarine cables will be established from Bornholm to Køge Bugt on Zealand and to Germany initially, and possibly other partner countries later. The onshore facilities on Bornholm will consist of underground cables and a new converter station in the south. The converter station on Bornholm is planned to support a 60 kV connection to the local grid, and large-scale electricity consumption (e.g. Power-to-X) or generation (e.g. large photovoltaic [PV] power plants) in the vicinity will be able to draw or add power directly via the energy island infrastructure.

FennoSkan 3 (FennoSkan 1 renewal)

Today, there are two submarine HVDC connections, in total 1,200 MW, between Finland and Sweden bidding area SE3. In TYNDP 2022, a potential new HVDC submarine cable project between FI and SE3 with a capacity of 800 MW was identified as FennoSkan1 is expected to be decommissioned by 2040. This new project, FennoSkan 3, could be potentially a hybrid project also connecting offshore wind power. However, the planning is still in the very early phase.

19 Bornholm Energy Island

9 Conclusions

This ONDP is the initial study of its sort for the BEMIP offshore grids corridor. MSs provided non-binding targets for this development plan, while TSOs investigated the consequences for the additional infrastructure. The study shows that the assessment of offshore hybrid projects can help to integrate offshore RES in the future. In the BEMIP area, there is already one hybrid project in operation and a second one foreseen for the 2030 time horizon.

For 2040, a North-East to South-West transmission corridor was identified as economically beneficial. For 2050, a further expansion of this North-East to South-West transmission corridor and a new East to West transmission corridor were identified.

The BEMIP ONDP 2024 also shows that there are some challenges for the offshore build out, which consist of possible spatial conflicts with other interests, and environmental impacts on offshore infrastructure, such as ground conditions and icing. To develop the infrastructure necessary to achieve the goals set by the MS targets and creating links where it makes sense, a joint effort by all stakeholders is required.

For future editions, the ONDP will be merged with the TYNDP. By performing an integrated analysis, insights on unlocking offshore RES potential and the connection between projects and to the onshore network can be improved.

Appendix

BEMIP Maritime Spatial Plans

According to the EU´s legal framework marine or maritime spatial planning (MSP) is the process for planning where and when human activities take place at sea. This is needed due to increased competition for space – from shipping, renewable energy, fishing, leisure and other activities.

These activities need to be coordinated in the best possible manner to reduce conflict and help meet environmental, economic and social objectives. The nations bordering the Baltic Sea are developing MSPs to fulfil their requirements under the EU Directive[20]. MSP activities in the Baltic Sea **available here**.

EU member state and Links to Policy	Summary Approach to MSP
Denmark Click on the name of the respective country to go to the policy	The Danish MSP for the sea was finalised and launched in March 2021. This new MSP introduces holistic spatial planning for the entire Danish marine area, including the marine internal waters, the territorial sea and the EEZ. The objectives of the plan are to promote economic growth, the development of marine areas, and the use of marine resources on a sustainable basis. The MSP includes several uses and activities, each of which is subject to different legislation and whose scope varies greatly. The MSP therefore allocates a significant part of the sea area for renewable energy so that there is room to establish the new OWFs and the world's first energy islands. The allocation of areas for OWFs means that Denmark also supports the EC's strategy for renewable energy at sea.
Estonia	The Estonian MSP is a national strategic document of spatial development in Estonian sea area. The spatial plan provides guidance and conditions for the next steps in the planning of activities, including those at a local government level. The spatial plan specifies the areas where maritime activities such as offshore wind generation, can be carried out, and under which conditions. The planning solution is based on environmental considerations and the best knowledge available. The conceptual locations of cable corridors in areas suitable for the development of wind energy in the marine area are arranged in such a manner that they consider Natura 2000 sites and their conservation objectives, i. e. do not affect them. The shortest possible distance to the connection point, the location and capacity of the existing transmission network and the development trends of electricity supply known today have also been considered important in the planning of connections.

20 European Union Directive

EU member state and Links to Policy	Summary Approach to MSP
Finland Click on the name of the respective country to go to the policy	The MSP is not legally binding in Finland but the assessment of its indirect and direct impacts and effectiveness forms part of the planning process. The first MSP for mainland Finland was adopted in December 2020. The MSP for the Åland Islands was compiled in March 2021. These plans indicate roughly 20 areas marked suitable for offshore wind generation. The mainland's MSP is planned to be updated at the latest in 2026 aiming, among others, to better consider offshore energy generation.
Germany	The revised MSP for the German EEZ in the North Sea and Baltic Sea entered into force on 1 September 2021. The plan coordinates the various uses in the EEZ, comprising shipping, offshore wind energy, cables, pipelines, raw material extraction, fisheries, research and defence. It reserves areas for individual uses and thus helps to minimise conflicts. A key objective of the MSP is to reconcile the mentioned uses with the ecological functions of marine space. The Federal Maritime and Hydrographic Agency (BSH) under the Federal Ministry of Interior, Building and Community is responsible for the preparation of the MSPs in Germany. Based on the guidelines of the MSP, the Site Development Plan makes determinations for OWFs and grid connections. The latest version was released in January 2023. Due to the dynamic developments in Germany regarding the offshore wind targets, the next Site Development plan is already in preparation. In Germany, Federal Coastal States are responsible for setting up spatial development objectives and principles for their respective share of internal waters and territorial sea in the North Sea and the Baltic Sea. Therefore, separate MSPs exist for the German North Sea and Baltic Sea EEZs and for the territorial sea areas under jurisdiction of the three coastal federal states (Lower Saxony, Schleswig-Holstein, and Mecklenburg-Vorpommern). The latest plan for the Baltic Sea from the federal state of Mecklenburg-Vorpommern is from 2016. The plan is renewed about every 10 years.

EU member state and Links to Policy	Summary Approach to MSP
Latvia Click on the name of the respective country to go to the policy	The Latvian MSP is a national level long-term (up to 12 years) spatial development planning document that shall define the use of the sea, considering a terrestrial part that is functionally interlinked with the sea and coordinating interests of various sectors and local governments in the use of the sea. The MSP covers territorial waters (out to 12 nautical miles) and the EEZ (from 12 nautical miles). The MSP has been established in accordance with the Spatial Development Planning Law (in force since 1st December, 2011). The law defines that the MSP shall lay down the use of the sea, considering a terrestrial part that is functionally interlinked with the sea and coordinating the interests of different sectors and local governments in the use of the sea. The MSP has also been elaborated according to Regulation No. 740 of the Cabinet of Ministers on the Procedures for the Development, Implementation and Monitoring of the Maritime Spatial Plan (in force since 30 October, 2012). According to Regulation No. 740 of the Cabinet of Ministers, the MSP is developed for the whole part of the Baltic Sea under the jurisdiction of the Republic of Latvia. **The four main categories for permitted uses of the sea are:** › Areas of priority interest – the category includes the existing and potential uses of the sea essential to ensure the achievement of the priorities. The areas are established for these types of uses of the sea by excluding or setting restrictions to activities which can cause disturbances or damage to their existence or development. Uses are: shipping, fishing, tourism, national security, nature conservation. › Areas of potential development: the category includes the potential uses of the sea (renewable energy; maritime tourism and aquaculture) for which the suitable areas are identified, considering limiting natural conditions and possible impacts to marine ecosystem, in addition to potential conflicts with other sea users. Uses are: offshore energy development, aquaculture development, tourism development. › Other types of the uses of the sea and marine features that have an informative character or its location and uses are defined by the existing regulation. Uses are: navigation and port information, navigation safety information, coastal tourism and recreation, diving, fishery, hydrocarbons, infrastructure, sewage discharge, wrecks › Areas of general use, where all sea uses are allowed, including fishery, shipping, tourism and leisure, research, etc., as long as they are in line with exiting legal requirements and do not cause significant negative impact to marine environment.

EU member state and Links to Policy	Summary Approach to MSP
Lithuania Click on the name of the respective country to go to the policy	The Lithuanian MSP is integral part of Comprehensive Plan of the Territory of the Republic of Lithuania (CPTRL). CPTRL is a spatial territorial planning document that defines spatial development aims and functional priorities for the use of territories, ensuring compatibility of strategic planning with spatial (territorial) documents valid in Lithuania. The new CPTRL is a system that ensures the spatial integrity of all country strategies. It was approved by Government resolution no 789. Annex 9 of Resolution no 789 is dedicated to the Responsible use of maritime and costal territories (MSP). MSP indicates all necessary elements of maritime territories such as protected areas, culture heritage areas, maritime and costal existing and possibly developed infrastructure, development of communication links with foreign countries, RES development areas, possible future energy corridors, and others.
Poland	On 14 April, 2021, the Council of Ministers adopted the Spatial Development Plan for Polish Maritime Areas. The plan designates areas dedicated to renewable energy, where it is possible to build OWFs, this area is 2,340 km² (10 % of the EEZ). Offshore wind farm projects will be developed in the Polish exclusive economic zone of the Baltic Sea in the area designated in the maritime development plan in the area of the Słupsk Bank, the Central Bank and the Oder Bank, where areas with renewable energy function are allowed in the plan. These are grey areas marked 14E (the Oder Bank), 43E, 44E, 45E and 46E on the Słupsk Bank and to the north of them area 60E on the Central Bank.
Sweden	Sweden adopted its first MSPs in February 2022. The current plans hold designated areas that can produce between 20–30 TWh of electricity per year. Directly after the first version of the Swedish MSPs were published, the government commissioned the Swedish Energy Agency and the Swedish Agency for Marine and Water Management with the task of reviewing the new plan and identifying supplementary offshore areas that allow for an additional 90 TWh per year. The new national ambition is thus that the revised Swedish national MSP will allow for up to 120 TWh of offshore electrical generation per year, corresponding to a combined capacity of some 29 – 33 GW. It is, however, important to note that national marine spatial plan is a non-binding guiding document only, i. e. final permitting is decided on a project-by-project basis. There are three distinct marine spatial plans in Sweden – the Western Sea (Skagerrak and Kattegat), the Baltic proper and the Gulf of Bothnia. There are significantly less conflicts of interest for offshore wind development in the Gulf of Bothnia compared with the Western Sea and the Baltic proper. Permitting in the Baltic proper is in general a complex matter as the likelihood that projects developed along Sweden's east coast conflict with defence interests is high.

Glossary

Term	Definition
ACER	The European Union Agency for the Cooperation of Energy Regulators
AOG	Atlantic Offshore Grid (priority offshore grid corridor – EU 2022/869)
BEMIP	Baltic Energy Market Interconnection Plan
BEMIP offshore	Baltic Energy Market Interconnection Plan offshore grids (priority offshore grid corridor – EU 2022/869)
EC	European Commission
EEZ	Exclusive Economic Zone: area of the sea in which a sovereign state has special rights regarding the exploration and use of marine resources, including energy production from water and wind. It stretches from the outer limit of the territorial sea (12 nautical miles from the baseline) out to 200 nautical miles (nmi) from the coast of the state in question. The EEZ does not include either the territorial sea or the continental shelf beyond the 200 nautical mile limit.
EU	European Union
ENTSO-E	European Network of Transmission System Operators for electricity: the European association for the cooperation of TSOs for electricity
IEA	International Energy Agency
IRENA	The International Renewable Energy Agency
MS	Member State of the European Union
MSP	Maritime Spatial Planning
NECP	National Energy and Climate Plan
NSCOGI	North Seas Countries' Offshore Grid Initiative (High level group; 2009 – 2015)
NSEC	The North Seas Energy Cooperation (NSEC) (High level group since 2016, follow-up to NSCOGI)

Term	Definition
NSOG	Northern Seas Offshore Grids (priority offshore grid corridor – EU 2022/869)
NT	National Trends – ENTSO-E scenario in the TYNDP22, building on countries' NECPs.
ONDP	Offshore Network Development Plan (new plan according to Art. 14.2 of EU 2022/869), part of ENTSO-E's TYNDP)
P2X	Power-to-X or conversion of renewable electricity into other forms of energy substances (such as gas, plastic, heat, chemicals etc)
PV	Photovoltaics
RES	Renewable Energy Sources
SB	Sea-basin
SB-CB	Sea-basin cost benefit
SB-CS	Sea-basin cost sharing
SB-ONDP	Sea-basin Offshore Network Development Plan
SE offshore	South and East Offshore Grids (priority offshore grid corridor – EU 2022/869)
SW offshore	South and West Offshore Grids (priority offshore grid corridor – EU 2022/869)
TEN-E	Trans-European Networks – Energy, refers to Regulation (EU) 2022/869 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2022 on guidelines for trans-European energy infrastructure, amending Regulations (EC) No 715/2009, (EU) 2019/942 and (EU) 2019/943 and Directives 2009/73/EC and (EU) 2019/944, and repealing Regulation (EU) No 347/2013
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan; generated and published by ENTSO-E every two years for electricity infrastructure and by ENTSOG for gas infrastructure

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The drafting team of this sea basin report is composed of the Members of the **ENTSO-E Regional Group Baltic Sea**, led by Michael Heit (50Hertz) and the TSO-collaboration Baltic Sea Offshore Grid Initiative (BOGI), led by Oleg Tsernobrovkin (Elering), supported by Brenda Pent (Elering).

Drafting Team

Lead

Oleg Tsernobrovkin . . . . Elering
Brenda Pent . . . . Elering
Michael Heit 50Hertz

Regional group and BOGI members

Andrzej Tymorek . . . . PSE
Angelica Waernlund . . . . Svenska Kraftnät
Anne Hommelgaard Falcon . . . . Energinet
Ansis Zbanovs . . . . AST
Arne Egil Pettersen . . . . Statnett
Ebrahim Shayesteh . . . . Svenska Kraftnät
Janne Seppänen . . . . Fingrid
Laura Ihamäki . . . . Fingrid
Lydia Weygoldt 50Hertz
Moritz Wienhold 50Hertz
Ramunas Bikulcius . . . . Litgrid
Robert Raczkowski . . . . PSE
Sophia Amalie Mortensen . . . . Energinet
Vaida Tamasauskaite . . . . Litgrid

Secretariat support

Iason Dizes . . . . ENTSO-E
Léa Dehaudt . . . . ENTSO-E
Thanh-Thanh Le Thi . . . . ENTSO-E
Xosé María Vega Arias . . . . ENTSO-E

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DreiDreizehn GmbH, Berlin . www.313.de

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