Offshore wind vessel availability until 2030: Baltic Sea and Polish perspective

Final Report

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WindEurope
POLISH WIND ENERGY ASSOCIATION
H-BLIX

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Over the next few decades, offshore wind will be one of the fastest developing renewable energy sources. Having that in mind, the Polish Wind Energy Association has decided to identify key obstacles in meeting the targets set for the offshore wind sector.

Offshore wind is also one of the key pillars of Poland's energy transition. Given the right conditions and adequate support, wind from the Baltic Sea can contribute to the country's energy security and to consolidation of the Polish economy through creation of a modern and stable supply chain. Poland may become a leader in offshore wind development in the Baltic Sea region and in Europe — we only need to properly estimate and subsequently harness the potential of the Baltic Sea. The currently planned 11 GW are already being verified in the government's update to Poland's Energy Policy until 2040 (PEP 2040).

The industry is also verifying these assumptions. According to the Polish Wind Energy Association, with proper planning we may achieve much more, therefore, the installed capacity potential will have to be re-assessed.

An important element in the discussion about the offshore wind sector is the increase in local content. It must be stressed that in order to build a strong offshore wind industry, having an installation port is essential. Therefore, I would like to emphasize the need for its construction on the Polish coast. A clear message and action in this field is needed to ensure implementation of Phase I projects through a Polish port — otherwise the investors will be forced to choose other locations or revise their project timelines.

In the opinion of the Polish Wind Energy Association, it is particularly important to raise the topic of installation vessels. Proper information on availability of vessels needed for the offshore wind sector is essential for developers and for vessels operators to get prepared for new challenges. The Polish Wind Energy Association and its partners have the pleasure to present this Report: Offshore wind vessel availability until 2030: Baltic Sea and Polish perspective – a detailed analysis of demand and supply of installation vessels and other types of ships required for offshore wind projects.

Proper information about demand and supply of vessels is crucial for planning future development of offshore wind projects. I believe that our Report will become a starting point for further discussion on the development of offshore wind energy and the construction of a strong European industry.

Piotr Czopek
Polish Wind Energy Association

POLISH WIND ENERGY ASSOCIATION

FOREWORD

Offshore wind is a success story made in Europe.

And the story is only just getting started.

Today Europe has 28 gigawatts (GW) of offshore wind farms in operation, 15 GW of which are in the EU. The EU's Offshore Renewable Energy Strategy envisages a 20-fold increase to 300 GW by 2050. Adding the additional volumes pledged by non-EU countries, Europe's total offshore wind capacity will comfortably exceed 400 GW by mid-century.

Europe has been a first mover in offshore wind development and built up a strong supply chain as well as a state-of-the-art fleet of dedicated offshore wind vessels. Offshore wind is a key driver of economic growth in coastal regions across Europe and has help revive ports and other towns. Europe's offshore wind industry currently provides 77,000 jobs. This is likely to more than double by 2030.

Russia's aggression in Ukraine is a painful reminder of Europe's current dependency on fossil fuel imports from Russia and elsewhere. In its new energy policy, "REPowerEU", Europe aims to reduce imports of Russian gas by two-thirds in 2022 and to wean itself of Russian fossil fuel imports completely by 2027. REPowerEU identifies offshore wind as one of the key drivers in tackling the over-reliance on fossil fuel imports, increasing the domestic production of renewables and strengthening Europe's energy security.

The EU is not alone in doubling down on home-grown and competitive offshore wind energy. National Governments in Europe have already pledged additional offshore wind volumes that would add up to 100 GW by 2030, overshooting the amount of offshore wind needed to deliver the current 55% emission reduction target and more than enough to fulfill the new 45% renewable energy target.

These increased ambitions require more skilled workers, investments in port infrastructure, optimized and reinforced onshore grid connections and a ramp-up of Europe's production capacities along the whole supply chain of offshore wind energy. They also translate into a sharply growing need for additional vessels – both for the installation of offshore wind farms and for service and maintenance.

But Europe not only needs more vessels to handle the logistical challenges that come with an expansion of offshore wind up to 300 GW by 2050. It also needs a new generation of vessels. Offshore wind turbines are rapidly increasing in size and weight. The largest offshore wind turbine installed in European waters today has 10 MW. Within this decade, we will see turbines with almost twice as much capacity. Manufacturers are already testing prototypes with up to 16 MW. This new generation of offshore wind turbines offers a great business opportunity for the European shipbuilding and maritime industry.

To take the right investment decisions, it's essential to take a closer look at Europe's current fleet of vessels and to understand future requirements. I want to thank the Polish Wind Energy Association for initiating this very timely and important report. It provides valuable insights in Europe's next generation of offshore wind vessels.

I hope you enjoy the read.

Giles Dickson, WindEurope CEO

FOREWORD

Energy is the lifeblood of the global economy. From heating our homes to powering our factories, everything we do depends on a reliable flow of affordable energy. The vision behind the UK Government's new, highly ambitious British energy security strategy is to bring clean, affordable, secure power to the people for generations to come but also help create a high-growth, high productivity, green economy across Great Britain – an economy fit for the 21st century. We are keen to accelerate our progress towards net zero, which is fundamental to energy security. By 2030, 95% of British electricity could be low-carbon and by 2035, we will have decarbonised our electricity system, subject to security of supply.

Offshore wind has already been a significant part of energy transition in UK. With more than 11,000 megawatts of capacity already in place, the UK has a very enviable record in this sector. In 2020 offshore wind accounted for 13% of total UK electricity generation. Our ambition is to deliver up to 50,000 megawatts by 2030, including up to 5,000 megawatts of innovative floating wind. The UK Government wants the UK to be at the heart of the global offshore wind industry.

Poland has also declared ambitious offshore wind development strategy. Although Poland is an emerging offshore wind market in Europe it offers significant potential within the Baltic Sea region.

Russia's invasion of Ukraine has highlighted the urgent need to end dependence on Russian energy and move towards a more secure and diverse energy supply.

The UK has already announced plans to phase out Russian oil imports and we will continue to work with our partners to end this dependence.

The UK is very keen to collaborate with Poland so the two countries can become greener together. The Clean Growth Partnership endorsed by our Prime Ministers is a key platform. We wish to deepen cooperation between Poland and the United Kingdom in relation to the development of offshore wind in Poland. This report is one of the examples of such collaboration and is also a good opportunity to showcase the UK's diverse and continuously evolving offshore wind export capability.

Our Department for International Trade facilitates business partnerships to help develop new offshore wind projects in the UK and overseas. They facilitate the development of the UK and Polish offshore wind supply chain with a view to developing our respective industrial capacities.

The huge volume of offshore wind to be built globally later this decade, coupled with the sheer size of the forthcoming generation of turbines and foundations, has left the sector facing a potential shortfall in capable installation vessels. Together with the Polish Wind Energy Association we endeavoured to analyse the potential bottlenecks in the supply chain in relation to the availability of installation vessels. I hope the conclusions from this report help developers mitigate risk so that projects can be delivered smoothly within the planned time schedule.

I encourage you to read this report and look forward to new business partnerships being formed for the benefit of our industries and the planet.

Anna Clunes

Her Majesty's Ambassador to Republic of Poland

British Embassy
Warsaw

Offshore wind power is one of the key solutions in our approach towards energy security, sustainable development and lower energy prices, in Europe as a whole and Poland in particular. I am therefore thrilled with the release of this report on offshore wind vessel availability, which will help to make our policy approach more concrete and illustrates the great opportunities it brings for our business communities.

The geopolitical shift that we are currently experiencing makes it very clear that we are entering a critical moment. We need to transform our energy system even faster than before. We need to secure and diversify our energy supply. We also need to keep driving decarbonization, since climate change will not be paused by geopolitical or military clashes.

In this light, expanding our offshore wind capacity is more urgent than ever, while also every day seems to bring a new challenge. War in Europe, interrupted energy supplies, shortage of materials, tightening labour markets, increasing costs, to name only a few. We cannot address these challenges individually. We will have to partner up, in both the public and the private sector, and across borders.

We therefore welcome the many offshore wind partnerships in Europe that are emerging. And there is potential for more cooperation. This report can help to pursue complementary partnerships between the Dutch and the Polish offshore wind community. The Netherlands brings vessel innovation, logistical support and installation capacity. Poland, potentially one of the largest offshore wind markets in Europe, brings scale and local expertise. By building partnerships in this domain we will, on the one hand, contribute to energy security and economic development and, on the other, to our fight against climate change.

We are impressed by the enormous efforts Poland is making to transform the Polish Baltic Sea into an valuable source of offshore wind energy, combined with building a solid local supply chain. Countries like Denmark, Norway, UK and the Netherlands have been pioneering in this industry. And will continue to do so. We invite Poland to join our group of frontrunners and materialize its potential to become a European hotspot for offshore wind. Hopefully, this report will be instrumental in kick-starting more partnerships, with which we can jointly solve challenges in the offshore wind energy community.

Daphne Bergsma, Ambassador of the Kingdom of the Netherlands to Poland

Kingdom of the Netherlands

High ambitions, collective effort and urgent action are needed to speed up the transition to a sustainable, climate neutral and environmentally friendly future. Norway has a close climate partnership with the EU, and together with the member states follows the energy-related directives and has its substantial input in achieving by Europe the goals of the European Green Deal and Fit for 55 package.

The necessity of speeding up the green shift has become even more important now due to the war in Ukraine and the need to balance the shortage of fossil fuel supplies from Russia.

Norway and Poland are important partners in energy transition. The main areas of the bilateral cooperation are the gas sector and renewable energy sources. The Baltic Pipe, transferring gas from the Norwegian shelf to Poland, will be ready built in September this year and in a short time it will allow to balance the amount of gas which was imported from Russia via the Yamal pipeline.

Norway has over one hundred years of experience from renewables, which stand for 98% of the country's electricity production. Apart from building up a strong hydropower sector, Norwegian companies have been active in developing other renewable energy sources, especially offshore wind, and in this field increasing cooperation between Poland and Norway is taking place. Norway has also a very well-developed offshore wind supply chain originating from the strong maritime sector as well as the oil and gas industries that have been developing for many decades.

We are happy that we could support the Polish Wind Energy Association in preparation of the "Offshore Wind Vessel Availability Report until 2030 in the Baltic Sea". The use of the highly advanced and specialized vessels from Norway is an important input into the development of the offshore wind sector in Poland and other countries around the Baltic Sea.

Anders Eide, Ambassador of Norway to Poland

Norwegian Embassy

Deployment of offshore wind continues to speed up globally, with more and more competitive prices. Ambitious declarations like the Esbjerg Declaration of May 18th, which sets a 150 GW target for the North Sea, supply chain issues will certainly intensify. This is already apparent when it comes to the availability of vessels that survey, install and service offshore wind farms.

To succeed with planned and future Baltic offshore wind farms, projects should be decisively executed – taking advantage of global best practices to ensure no lease-days are wasted and project costs are minimized. Denmark is committed to the success of offshore wind in the Baltic Sea since it is key to both energy security and the green transition of Europe. Furthermore, we expect it to be a driver of economic development and regional investments. Especially if the right vessels can be secured at the right times.

Ole Toft, Ambassador of Denmark to Poland

ROYAL DANISH EMBASSY
Warsaw

ACKNOWLEDGEMENTS

This report presents results of a study to understand a potential gap between supply and demand of offshore wind vessels until 2030. The report is a project of H-BLIX in Poland and BLIX Consultancy in the Netherlands with strong cooperation from WindEurope and the Polish Wind Energy Association.

The report has been prepared to a large degree on the basis of publicly available data from many different sources which are acknowledged in the text of the report. A very valuable insight for the report, considering both capacity forecast for the demand side and various trends for the supply side, has come from the information and statistics made available by WindEurope. In addition, to confirm some of the input data, identified trends and results of the analysis, H-BLIX and BLIX Consultancy representatives performed a number of interviews with contractors, shipbuilders and cable manufacturers as well as selected Polish and international developers.

As a result, the authors of the report would like to extend their special thanks to:

- Piotr Czopek of PWEA for project oversight as well as excellent input to the report from Polish market and industry perspective;
- Lizet Ramirez of WindEurope for provision of data and information as well as her invaluable input to the report throughout its preparation;
- Daniëlle Veldman of NWEA for her creative ideas and sharing her extensive network;
- Oliwia Mróz of PWEA for verification of the report;
- All participants of the interviews, meetings and discussions for their insight on the global offshore wind vessel market as well as risk and challenges, including those specific to Poland.

In addition, special thanks need to be extended to all project sponsors, including (in alphabetical order): British Embassy Warsaw, the Netherlands Embassy in Warsaw, Norwegian Embassy, Norwegian Energy Partners, Royal Danish Embassy Warsaw, Scottish Development International and WindEurope, for their financial and non-financial support in report preparation.

About partners

WindEurope

WindEurope is the voice of the wind industry, actively promoting wind energy across Europe, which associated over 400 members from across the whole value chain of wind energy: wind turbine manufacturers, component suppliers, power utilities and wind farm developers, financial institutions, research institutes and national wind energy associations.

WindEurope actively coordinates international policy, communications, research and analysis. They also provide various services to support members' requirements and needs in order to further their development, offering the best networking and learning opportunities in the sector. Additionally, the lobbying activities undertaken by WindEurope help create a suitable legal framework within which members can successfully develop their businesses. WindEurope produces a large variety of information tools and manages campaigns aimed at raising awareness about the benefits of wind and enhancing social acceptance, dispelling myths about wind energy and providing easy access to credible information.

WindEurope regularly organises numerous events, ranging from conferences, exhibitions, and launches to seminars and workshops. These encourage the exchange of international experience on policy, finance and technical developments, and provide the ideal forum in which to showcase the latest technology.

About partners

Industrial Development Agency JSC

Industrial Development Agency JSC (IDA or ARP) is a state-owned, join-stock company under ownership supervision of the Chancellery of the Prime Minister of the Republic of Poland.

The Industrial Development Agency JSC:

- Plays a major role in increasing competitiveness of the Polish industry;
- Supports business enterprises in operation and development of business activity, as well as in the implementation of restructuring processes.

Grupa Przemysłowa Baltic (GP Baltic) is an integrator of group of companies created as a response to constantly growing market expectations:

- It combines the strengths and possibilities of leaders on the Polish and European market of large, multidisciplinary steel structures as well as the broadly understood maritime industry;
- It is a solution for the need of a professional and experienced fabricator of new alternative Energy sources as well as the development of now existing solutions for wind, oil, mine and nuclear energy.

Strategy to work as one group made from two companies in 3 locations both Gdansk and Gdynia exchanging experience, competitive advantages and the possibility of using the strengths of all facilities concerning different projects and type of products.

NORWEP

Norwegian Energy Partners (NORWEP) is an independent non-profit foundation established to strengthen value creation in the Norwegian energy industry through expanding the industry's international business activities. NORWEP is acting as a catalyst for processes between Norwegian industry and international businesses and governments. NORWEP has more than 300 independent, operating companies as partners.

How do we work?

We map competence, technology and comparative advantages of Norwegian companies and match this with customer demands internationally. Our aim is to strengthen the position and competitiveness and at the same time reduce the risks related to international activities. We work as a network organization bringing customer and suppliers together. NORWEP's work is based on customer orientation, cooperation, finding solutions, respect, integrity, and competence.

Our founders are the Norwegian Shipowners' Association (Norges Rederiforbund), the Federation of Norwegian Industries (Norsk Industri), the Norwegian Oil and Gas Association (Norsk olje & gass), Energy Norway (Energi Norge), Equinor, Statkraft, the Norwegian Confederation of Trade Unions (LO), Ministry of Trade, Industry and Fisheries, Ministry of Petroleum and Energy and Ministry of Foreign Affairs.

About partners

Scottish Development International

Scottish Development International is Scotland's trade and foreign direct investment agency. Our aim is to encourage and support more overseas businesses to set up a location here, invest in Scottish businesses or buy high quality Scottish products and services.

The Agency does this by providing information, partnering with businesses and investors who want to set up or invest here, and helping businesses find the connections they need.

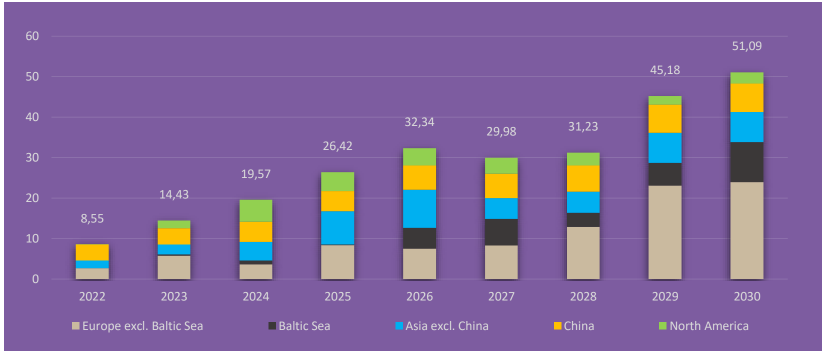
They can also help businesses around the world access the huge range of high-quality products and services offered in Scotland.

- The main objective of this report is to assess the availability of offshore wind vessels in 2030 perspective, with specific focus on Baltic Sea and Poland. The assessment has been performed on the basis of a demand versus supply analysis.

- Key results of the demand analysis, which was performed in the form of offshore wind installation capacity forecast until 2030 are as follows:
  - The current, already high growth of offshore wind market will experience significant acceleration, especially towards the end of the decade. The 2021 globally installed capacity of 57 GW is to increase over 5 times to 316 GW by 2030. The above growth is to be led by Europe, which, in 2030, is going to account for almost 50% of the global offshore wind market (increase from 28 GW in 2021 to approximately 156 GW in 2030);
  - In Europe meeting the recently announced government targets will result in an unprecedented growth in new installations between 2029 and 2030. The capacity forecasted to be commissioned in 2029 may exceed the total volume being online in 2021 (28 GW), and this figure is still significantly smaller than the 2030 installation forecast of some 33,8 GW;
  - Even higher growth rate is predicted for the Baltic Sea, including Poland. As shown in Figure 1, the total volume by 2030 is to reach ca. 35 GW (from 2,8 GW in 2021), with rapid acceleration for the period 2026 – 2030 (nearly 31 GW to be installed in 5 years).

- The forecasted capacity to be installed in any given year has been translated into vessel demand considering an average vessel productivity coefficient in [GW/vessel/year]. The coefficient has been calculated for each year considering a number of factors such as e.g. average project size, average turbine size, maximum number of working days per year, required time for installation as well as standard project activities such as transit, (de)mobilization and loading, and other effects such as delays due to weather, (logistical) inefficiency, etc. Results of the above analysis are presented under heading „Productivity analysis" in Part 4, 5 and 6 of the report.

Figure 1 – World: New installations in the world to 2030 [GW]



Source: H-BLIX based on information from WindEurope, GWEC 2021 [D1], GWEC 2022 [D2] and investor provided information (publicly available) for Baltic Sea projects

- For the Baltic Sea and Poland a theoretical upper and lower boundary of vessel demand numbers have been calculated, considering the number and capacity of forecasted projects.
- A supply analysis has been performed considering the identified installation vessels (formerly) active in offshore wind market (Appendix B). For wind turbine installation vessels (WTIV) and foundation installation vessels (FIV), assets have been categorized to assess their suitability for installation of forecasted turbine and foundation size in a specific year. This allowed to determine the number of worldwide available vessels suitable for installation in a specific year. For cable laying vessels (CLV) no categorization has been applied as developments in cables are not expected to imply a reduction in suitability.
- The results of the supply analysis indicate an increase in a number of suitable installation vessels until 2026. From that time onwards the number of suitable FIV and WTIV decreases due to the increase in turbine and foundation sizes. Details regarding vessel supply trends can be found under section „Supply" in Part 4, 5 and 6 of the report.

- As shown in Figures 2, 3 and 4, due to significant demand growth, there is a shortage of installation vessels.
- For WTIV demand peaks in 2025-26 and then 2029-2030 (Figure 2) with 2025 supply vs demand gap greater than the Baltic See demand and significant shortage towards the end of the decade.
- For FIV and CLV demand peaks in 2024-2025 and then 2028-2030 with very similar rations and trends for the Baltic Sea.
- The current Offshore Supply Vessel (OSV) market is oversupplied but to a certain extend underqualified, and due to legislative and project requirements expected to be a challenging market in the second half of this decade. Suitable OSVs are contracted for longer term by parties with large project portfolios, making it hard for stakeholders with smaller portfolios. The demand for suitable vessels creates an opportunity for local shipyards worldwide, be it in conversion or newbuild.

Figure 3 – FIV demand versus supply - worldwide

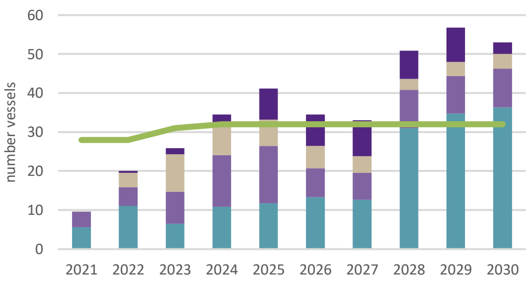


Figure 2 – WTIV demand versus supply

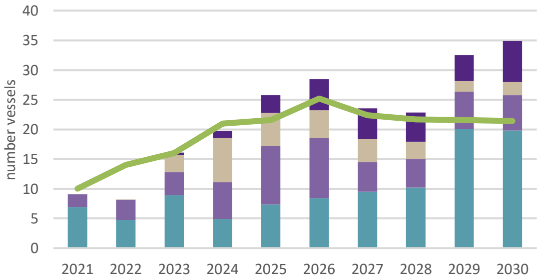
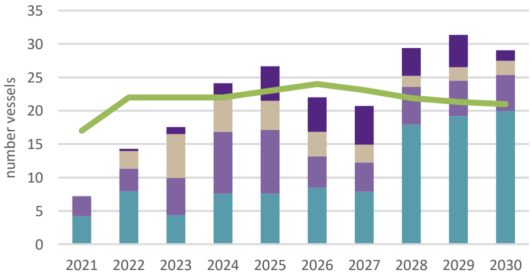


Figure 4 – CLV demand versus supply



Baltic required vessels | Americas required vessels | Asia ex China required vessels | Europe ex Baltic required vessels | Suitable vessels world ex China

Source: H-BLIX

- Considering the results of the analysis, the authors presents 12 key conclusions, which have been elaborated further in Part 8 of the report:
  1. Accelerated growth in offshore wind capacity installation towards 2030, both worldwide as well as in the Baltic Sea and Poland;
  2. First shortage of FIY and WTIV in 2024 and 2025 respectively, followed by a drop in the demand for next two years;
  3. Very significant shortage of FIV and WTIV in the period 2028 – 2030, which can be bridged on time by new vessels;
  4. Similar shortage pattern for CLV (2024 – 2025 and 2028 – 2030) with even greater gap to be bridged;
  5. Worldwide shortage of FIVs, WTIVs and CLVs poses risk for project execution worldwide as well as in the Baltic Sea and Poland;
  6. Considering the potential shortage, it is vital for the Baltic Sea and Polish Wave I projects to secure the availability of installation vessels as soon as practically feasible;
  7. Forecasted shortages in supply versus demand may be bigger than presented due to large unforeseen events not taken into account in the analysis;
  8. The shortage of vessels appears to be due to difficult business case for new builds and a number of risks which need to be addressed by the governments and the industry;
  9. Providing the aforementioned gaps are bridged on the worldwide basis and the 35 WTIV, 32 FIV and 57 CLV are in operation by 2030 then ca. 47 GW of new offshore wind capacity could be added annually;
  10. Availability of SOVs should not pose a problem for O&M activities, but do require a significant investment in newbuild or conversions to meet project needs;
  11. Considering Baltic Sea and Polish offshore wind potential, Poland may use the currently developing opportunity to create an offshore wind industry to serve local and international markets;
  12. To become a significant player in the offshore wind industry Poland may need to address a number of challenges, especially related to regulatory framework and installation port(s).

In summary:

The worldwide installation vessel shortage is a risk to planned project execution, and some project developments may have insufficient or in a worst case scenario no installation asset at their disposal.

The shortage is expected to lead to a deficiency in installation of annual installed capacity and hence reaching the 2030 government targets.

To ensure in time installation of set targets, it is key that both the EU and local governments facilitate offshore wind development by creating the right conditions in terms of legislation, funding, supply chain and infrastructure as well as by creating proper conditions for the investment in installation vessels.

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PART 1: Introduction

Acronym / Name	Explanation / definition
AC	Alternating Current
amsl	Above mean sea level
BEMIP	Baltic energy market interconnection plan
CAGR	Compound Annual Growth Rate
CfD	Contract for Difference
CLV	Cable-laying vessel
COD	Commercial Operation Date
CTV	Crew transfer vessel
DC	Direct Current
DP	Dynamic Positioning
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ERO	Energy Regulatory Office
FID	Final Investment Decision
FIV	Foundation Installation Vessel
GWEC	Global Wind Energy Council
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current

Acronym / Name	Explanation / definition
JV	Joint Venture
LCOE	Levelized Cost of Energy
MSP	Marine Spatial Plan
NCEP	Latvia’s National Energy and Climate Plan 2021 – 2030
O&G	Oil and Gas
O&M	Operation&Maintenace
OWF	Offshore Wind Farm
OSS	Offshore Substation
OSV	Offshore Support Vessel
RES	Renewable Energy Sources
SOV	Service Operation Vessel
TSO	Transmission System Operator
TYNDP	The 10-year network development plan
WTG	Wind Turbine Generator
WTIV	Wind Turbine Installation Vessel

Objective

In an effort to limit global greenhouse gas emission and most recently due to new geopolitical situation associated with the war in Ukraine, many countries around the world and especially those in Europe and the EU have decided to significantly restructure their power generation mix, with offshore wind being one of the key elements on the agenda. At political level, during the last few months and most recently on May 18th 2022 through the Esbjerg Declarations, a number of countries have committed to even higher targets for offshore wind and many others, including Poland, are in the process of revising them.

The execution of the new, very ambitious targets require amongst others more efficient permitting and wind farm development processes, greater cooperation amongst involved countries and a significant increase in supply chain capacity, including production and installation capacity.

As a number of previous studies have shown, an insufficient number of offshore wind vessels could become a global bottleneck. Due to a relatively long construction time (approx. 3-4 years from order placement) and the growing worldwide offshore wind project pipeline, further undersupply of installation and other offshore wind vessels is predicted, with the expected gap being even greater due to most recently announced capacity targets.

As the risk of offshore vessel shortage may have far reaching consequences and the vessel availability reports published so far have a global focus, **the Polish Wind Energy Association decided to analyze the question of offshore wind vessel availability from a more local perspective. As a result, the main objective of this report is to assess the availability of offshore wind vessels in 2030 perspective, with specific focus on Baltic Sea and Poland**.

Information on the availability of vessels needed for the offshore wind sector is essential not only for developers and vessel operators, but also for other supply chain players such as shipyards as well as governments, which may decide to create special conditions for local content development in this area.

Scope

Considering its objective, the report presents results of a detailed offshore wind vessel supply vs demand analysis and consists of:

- A general overview of the current status of the global offshore wind energy market and installed capacity at the end of 2021;
- Demand analysis in the form of offshore wind installation capacity forecast until 2030, taking into account global and regional perspective, but also zooming into the Baltic Sea and Poland, with an overview of actual capacity development potential until 2030, based on projects currently being developed / considered in the context of regulatory framework in a particular country;
- Analysis of some key offshore wind trends, focusing on turbine and foundation sizes, as well as water depth, which impact offshore wind vessel suitability;
- Supply analysis in the form of examination of currently available and to be commissioned foundation installation vessels (FIV), wind turbine installation vessels (WTIV), Cable Laying Vessels (CLV), considering factors such as for example:
  - Vessel suitability (parameters) to handle e.g. turbines and foundations in line with their predicted sizes;
  - Regional regulations, e.g. Jones act in the USA;
  - Physical constraints: Baltic Sea entry / exit;
- Vessel based supply vs demand analysis, taking into account global and regional perspective, but also zooming into the Baltic Sea and Poland, with a detailed analysis considering constraints coming from site characteristic and environmental impact assessment (EIA) decisions;
- General analysis of Service & Operation Vessels (SOVs);
- Conclusions, which may be inferred from the performed analysis, including also results of interviews with a number of industry players from Europe and Poland.

Methodology

Project pipeline

While the focus of this report is on the Baltic Sea and Poland, these markets cannot be analyzed and assessed without their broader worldwide context. The analysis therefore addresses a global picture before focusing on the Baltic Sea and Poland in detail. China has been excluded from the global assessment as both their market and vessels are generally considered not available to the rest of the world.

Global and European offshore wind market status and forecast data have been gathered from the latest studies performed by Global Wind Energy Council (GWEC) and 4C Offshore as well as data received from WindEurope. Results have been validated, and where necessary updated, based on publicly available information. Efforts have also been made to include the latest targets announced by individual governments (e.g. Germany, UK, the Netherlands) for offshore wind capacity by 2030*. For analysis purposes, the worldwide project pipeline has been determined based on worldwide offshore wind development targets and global trends to estimate the number of projects, turbines, foundations and cables to be installed worldwide.

The Baltic Sea demand has been estimated by means of a comprehensive analysis based on multiple sources, to estimate this region's future growth in detail. Using publicly available information, including wind farm specific reports and information released by various investors, a project pipeline was determined, which was then subject to a feasibility assessment through 2030. On this basis, a range of information about each project was collected, such as planned capacity to be installed, the number of turbines, average water depth, distance from shore, planned period of construction, etc.

For Poland, Wave I project information has been obtained from public sources made available by developers, which in a number of cases were validated and detailed through direct discussions, considering planned periods of foundation and turbine installation. This detailed data enabled to prepare forecasts of the capacity to be commissioned by 2030, which supported the accuracy of further calculations for both Poland and the Baltic Sea.

*The report captures offshore wind targets announced on or before 31st May 2022

Vessel supply

The worldwide installation vessels have been assessed based on their capabilities, to come to a fleet that is available for installation of offshore wind. Depending on the component installed, this assessment has been performed based on maximum lift height above sea level for Wind Turbine Installation Vessels (WTIV), maximum lift capacity at 30 m crane reach for Foundation Installation Vessels (FIV), carousel weight capacity for Cable-laying Vessels (CLV) and maximum lift capacity at 30 m crane reach for offshore substation (OSS) installation. Vessel suitability has been determined considering the above parameters vs current and forecasted turbine and foundation sizes, which were estimated by H-BLIX on the basis of information gathered from publicly available sources and interviews with various offshore wind industry representatives (details regarding the above can be found in Part 3 of this report).

Supply versus demand

To determine the number of turbines, foundations, cables and OSS to be installed in 2021-2030, a number of sources have been used to estimate the status of trends in 2021 and 2030. Changes over 2022-2029 and 2031-2032 have been estimated by linear inter/extrapolation.

The number of vessels required to install the annual forecasted offshore wind capacity has been calculated by means of a coefficient expressed in GW per asset per year, considering trends as presented in Table 1. Further details on identified trends can be founds in Part 3 of this report.

Table 1 – Assumptions used for the analysis

World ex China	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Avg. project size [GW]	0,40	0,49	0,58	0,67	0,76	0,84	0,93	1,02	1,11	1,20	1,29	1,38
Avg. turbine size [GW]	8,2	9,1	10,0	10,9	11,8	12,7	13,6	14,5	15,4	16,3	17,2	18,1

Source: H-BLIX analysis based on GWEC and 4C Offshore

Offshore substation (OSS) installation is assumed to take place 2 years prior to turbine installation, foundations and cables are assumed to be installed 1 year prior to turbine installation.

Methodology – continue

Considering the assumptions presented on previous page, the following has been calculated:

- **Number of turbines & foundations**: based on forecasted average turbine size in [MW/turbine] in line with WindEurope and 4C Offshore forecast;
- **Number of inter arrays:** multiplying the number of turbines by 1,1 to account for expected redundancy to be implemented;
- **Length of export cable:** based on cumulative global export cable installation length forecast over 2021-2030 by Renewable UK [S6], corrected for the market excluding China. The yearly installed export cable length is taken proportional to forecasted yearly added capacity.
- **Length of interconnectors:** based on pipeline up to 2030 as described in the 10-year network development plan (TYNDP) 2020 [D13], factored with 1,5 to take into account interconnector market outside Europe;
- **Number of joints:** 1 per every 30 km, estimated based on carousel capacity and approximate cable weight of HVAC and HVDC cables;
- **Number of OSS:** assuming 50% DC, on average 1,25 OSS per 1,2 GW in line with WindEurope Vision for EU Ports [D14].

The number of average size projects that can be executed per asset per year has been determined by calculating how many of these projects fit into a vessels maximum number of working days per year, which was estimated as 300 days (365 – yearly vessel maintenance and general non working time). For each project execution the analysis takes into account an average installation time per installed unit and an expected additional time per project for mobilization and demobilization, transit to project site, as well as delay proportional to installation time due to e.g. waiting on weather, (logistical) inefficiency, daily maintenance, etc. In addition, the fact that contactors will not completely fill their maximum number of working days per year (as this introduces a significant risk of knock on effects between projects) is taken into account.

The installation capacity in [GW/asset/year] is determined by multiplying the number of projects an asset can execute with the average project size [GW].

As OSS foundation and topside installation are relatively short "in between" jobs not filling the entire orderbook for heavy lift vessels, time required to execute these projects has been taken into account in the FIV analysis. The impact has been determined based on the number of OSS's to be installed, deducting required installation time averaged over the FIV fleet from the maximum number of working days per year.

Offshore support vessels (OSVs) are required during construction (e.g. bubble curtain support vessels) as well as during wind farm operation (e.g. crew transfer vessels (CTVs) and service operating vessels (SOVs)). The availability assessment has been made qualitatively from a world perspective. For the Polish projects an quantitative assessment based on wind farm size and distance to port has been made to determine the required number of OSVs during wind farm operation.

Supply versus demand - Baltic Sea

The number of assets required to install the forecasted capacity in the Baltic Sea per year has been determined based on concrete foreseen project pipeline.

Using the same parameters and assumptions as for the worldwide assessment, an upper and lower boundary vessel demand until 2030 has been calculated for the Baltic Sea and Poland specifically. A theoretical upper boundary of required vessels has been determined assuming there is very limited cooperation between stakeholders, meaning each project requires a separate vessel, and only part of the maximum number of working days per vessel per year is actually used. In case a project size is such that it exceeds the installation capacity of one vessel in a year, a correspondingly higher integer number of vessels is assumed. A theoretical, lower boundary of required vessels is determined assuming full cooperation between stakeholders, and thereby completely filling the maximum number of working days per vessel per year.

PART 2: Offshore wind market outlook

GLOBAL OFFSHORE WIND MARKET HAS BEEN GROWING RAPIDLY IN RECENT YEARS. THE BALTIC SEA HAS VERY SIGNIFICANT OFFSHORE WIND DEVELOPMENT POTENTIAL.

World and Europe

The global offshore wind market has clearly accelerated in recent years. This has been due to rapid technological advancements causing significant drop in Levelized Cost of Energy (LCOE), which made it even easier for various governments to increase their countries' offshore wind targets with the aim to reduce the usage of fossil fuels. Considering the current geopolitical situation, the pace of this acceleration may even increase, as especially Europe will drive their economy to become less and less dependent on Russian coal, oil and gas supply.

As reported by GWEC in their 2021 Global Offshore Wind Report [D1], the global offshore wind market grew on average by 22% each year in the period 2011-2020, reaching 36 GW of total installed capacity at the end of 2020. Thanks to significant increase in new installations in 2021, which were driven mainly by China (almost 17 GW), the global offshore wind capacity by the end of that year reached over 57 GW [D2].

On the country basis, considering the 2021 figures presented in Table 2, with 27,68 GW installed, which represents over 48% of world's total, China is currently a world leader in offshore wind, well ahead of the UK (12,52 GW, 21,9%) and Germany (7,73 GW, 13,5%). Total installed capacity in other major offshore wind European counties, such as the Netherlands, Denmark and Belgium equals to that of Germany, which shows the UK-Germany leadership in the European offshore wind market.

From the global perspective it is also worth noting a very similar capacity installed in Europe and Asia-Pacific (28 GW vs 29 GW respectively), with the rest of the world, including the US, being just at the beginning of the offshore wind journey.

Table 2 – Offshore wind market status [MW]

	New installations 2020	Cumulative 2020	New installations 2021	Cumulative 2021
Total	**6852**	**36077**	**21106**	**57176**
Europe	**2936**	**24837**	**3317**	**28154**
United Kingdom	483	10206	2317	12522
Germany	237	7728	0	7728
Belgium	706	2262	0	2262
Denmark	0	1703	605	2308
Netherlands	1493	2611	392	3003
Other Europe	17	327	4	331
Asia – Pacific	**3905**	**11199**	**17788**	**28980**
China	3845	10780	16900	27680
South Korea	60	133	0	133
Other APAC	0	285	888	1167
USA	**12**	**42**	**0**	**42**

Source: GWEC 2022 [D2]

Baltic Sea and Poland

The Baltic Sea area, including the Polish exclusive economic zone (EEZ), has been recognized as having very favorable conditions for offshore wind development. Not counting Germany and Denmark, and some smaller volumes in Sweden and Finland, the Baltic Sea countries, have so far been concentrating on maritime spatial plans (MSPs), elaboration of legislative framework and project development. As a result, the total offshore wind capacity installed in the Baltic Sea equals only to 2,8 GW [ref. WindEurope], which constitutes ca. 10% of European and ca. 5% global installed capacity. However, in the near future, the Baltic Sea, besides the North Sea, is to become a major offshore wind European hub.

THE RAPID GROWTH OF OFFSHORE WIND WILL CONTINUE AT EVEN HIGHER PACE. FROM 2025 ONWARDS EUROPE WILL BE A WORLD LEADER IN OFFSHORE WIND.

World

The rapid growth of offshore wind will continue. In line with H-BLIX forecast based of Commercial Operation Date (COD), globally installed capacity is going to increase from the 2021 figure of just over 57 GW to ca. 159 GW in 2026. During the following four years (2027 – 2030) the installed capacity is going to be almost doubled, reaching ca. 316 GW in 2030.

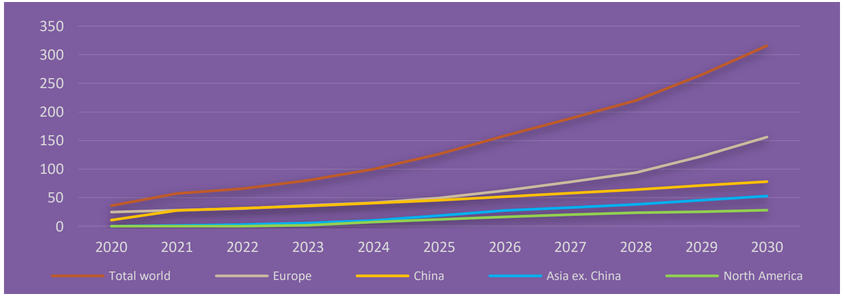
As shown in Figure 5, the above growth is to be led by Europe, which, in 2030, is going to account for almost 50% of the global offshore wind capacity. Significant growth is also expected in China and other Asian counties, with the US making a good progress as well. To put the forecasted growth into perspective, the total installed capacity in Europe in 2030 (156 GW) will be over 2,7 time greater than the 2021 global capacity (57,18 GW).

As presented in Figure 6, the offshore wind capacity installed each year between 2022 and 2026 will raise significantly on an annual basis. In fact, the predicted volume to be commissioned in 2026 will be almost 4 times the volume in 2022. The second large step in annually commissioned volume is predicted for 2029 and 2030 with over 45 GW and 51 GW respectively. This means that the capacity installed in 2030 will be 6 times greater than in 2022, and that the annual installations in 2030 will reach almost 90% of the total capacity installed so far.

Looking at Figure 6 it is also worth noting that while the predicted capacity to be commissioned in China will be maintained at a very similar level over the period 2022 - 2030, the capacity in Europe in going to raise every year from 2024 onwards. In fact, between 2027 and 2028 Europe will count for ca. 50% of new installations globally and in 2029 and 2030 for 63% and 66% respectively.

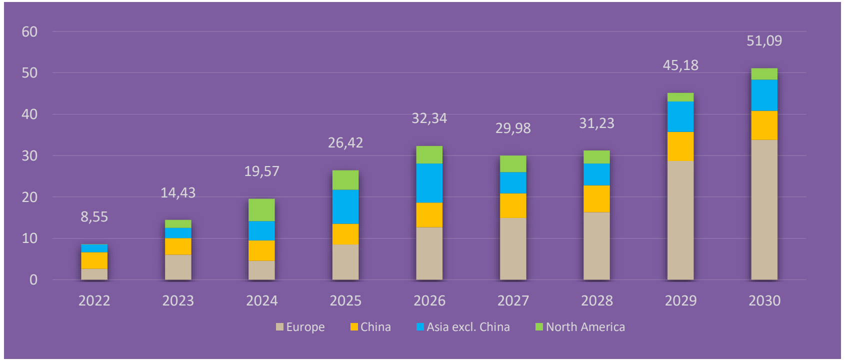
The offshore wind energy market and presented figures could accelerate even further by 2030 and beyond, especially considering pressure arising from the current geopolitical situations.

Figure 5 – World: Offshore wind total installed capacity until 2030 [GW]



Source: H-BLIX based on information from WindEurope, GWEC 2021 [D1], GWEC 2022 [D2].

Figure 6 – World: New installations in the world to 2030 [GW]



Source: H-BLIX based on information from WindEurope, GWEC 2021 [D1], GWEC 2022 [D2].

PROVIDING SET TARGETS ARE MET, WITH RAPID CAPACITY INCREASE, ESPECIALLY TOWARDS THE END OF THE DECADE, EUROPE WILL BECOME AN OFFSHORE WIND LEADER

Europe

Europe is considered to be a birthplace of the offshore wind. Providing set targets are met, Europe is to lead the global offshore wind growth, overtaking China in total installed capacity from 2025 onwards. From long term perspective, at the EU level, the target is to reach 300 GW in offshore wind capacity by 2050, which together with the UK and Norway totals 450 GW by that time. From the 2030 perspective many European countries have set their own targets, which are presented in the Table 3 below.

Table 3 – Government targets for offshore wind energy to 2030 [GW]

Country	UK	Germany	Netherlands	Belgium	Denmark	France	Poland	Ireland	Rest*
Target	50	30	21	5.8	10	6,8	5,9	5	12,1

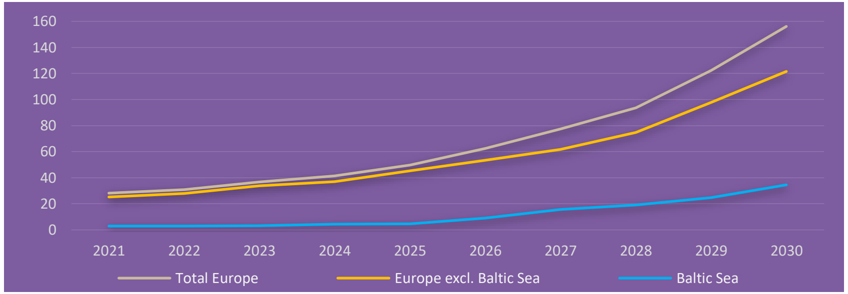
Source: H-BLIX based on Esbjerg Declaration, announced targets presented publicly available sources and information provided by WindEurope (*Rest – Greece, Italy, Lithuania, Norway, Portugal, Romania, Spain)

In line with Figure 7, the total offshore wind capacity is going to increase 5,6 times between 2021 to 2030, from the current figure of ca. 28 GW to ca. 156 GW. In other words, over the next 9 years Europe plans to install 128 GW, with significant acceleration towards the end of the decade to meet the defined targets. In fact, the capacity forecasted to be commissioned in 2029 exceeds the total volume being online in 2021 (28 GW), and this figure is still significantly smaller than the forecasted volume of some 33,8 GW in 2030.

At the country level, the UK will remain an European leader with consistent annual progress, installing some 30 GW between 2022 and 2030, and reaching a total installed capacity (bottom fixed) of ca. 43,5 GW in 2030 (5 GW is to be floating by 2030). Germany and the Netherlands will remain in the second and third place respectively, significantly accelerating their commissioned volume in 2029 and 2030 (see Figure 8 for details).

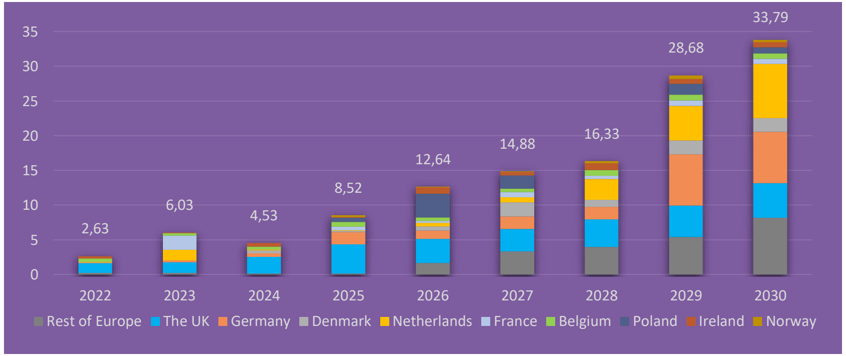
In addition to the offshore market leaders mentioned above, the growth will also come from projects in new markets that are already actively developing their projects (e.g. Poland, Sweden, France or the Baltic States – see the next page for details).

Figure 7 – Europe: offshore wind total installed capacity until 2030 [GW]



Source: H-BLIX based on information from WindEurope, GWEC 2021 [D1], GWEC 2022 [D2].

Figure 8 – New installations in Europe based on COD date [GW]



Source: H-BLIX based on information from GWEC 2021 [D1], WindEurope.

THE BALTIC SEA WILL BECOME A MAJOR OFFSHORE WIND EUROPEAN HUB. ITS INSTALLED CAPACITY WILL EQUAL TO 22% OF TOTAL EUROPEAN VOLUME.

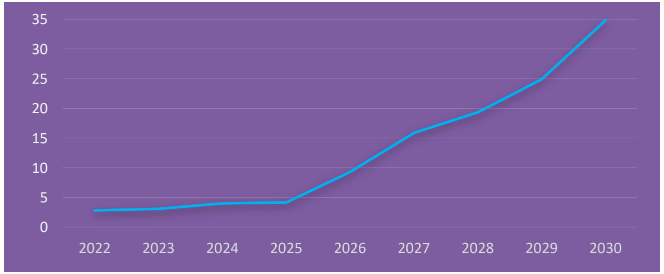
Baltic Sea

The Baltic Sea has a total area of 397,978 km² and borders nine countries: Germany, Denmark, Sweden, Finland, Estonia, Latvia, Lithuania, Russia and Poland. The Baltic Sea has very favorable conditions, such as shallow waters (average depth of ca. 54 m), high average wind speeds (ca. 9 m/s at 100 m amsl), low wave heights and weak tides, which result in relatively low LCOE values for offshore wind energy production.

As presented on the previous page, with a total of ca. 35 GW by 2030, the offshore wind capacity installed in the Baltic Sea will constitute ca. 22% of the volume commissioned in Europe.

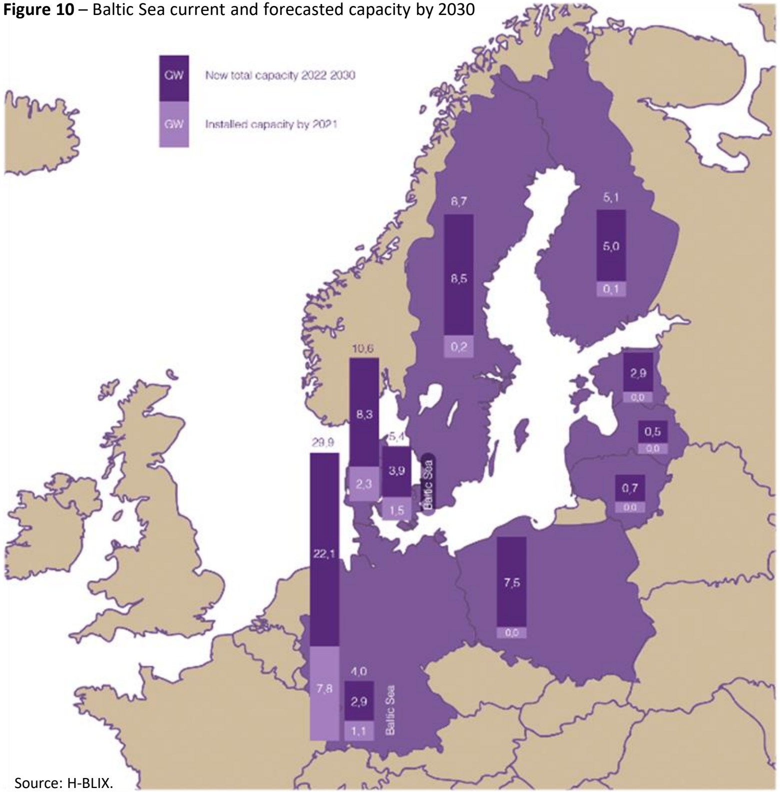
While the current installed capacity in the Baltic Sea is only 2,8 GW, this figure is expected to raise rapidly, especially from 2025 onwards (Figure 9). In fact, projections made by H-BLIX, on the basis of information provided by WindEurope and forecasts available from other publicly available sources, show total capacity reaching ca. 10 GW in 2026 and ca. 35 GW in 2030. Figure 10 presents currently installed and forecasted capacity by Baltic Sea country.

Figure 9 – Baltic Sea: offshore wind total installed capacity until 2030 [GW]



Source: H-BLIX based on publicly available information, such as investor and project specific reports and websites.

Figure 10 – Baltic Sea current and forecasted capacity by 2030



Source: H-BLIX.

THE BALTIC SEA WILL BECOME A MAJOR OFFSHORE WIND EUROPEAN HUB. ITS INSTALLED CAPACITY WILL EQUAL TO 22% OF TOTAL EUROPEAN VOLUME.

Baltic Sea

As presented in Figure 11, the progress in the 2026 perspective will be made mainly thanks to Poland (2,6 GW), but with some contribution from Germany, Denmark, Finland and Sweden. Between 2027 and 2030 the main contribution to offshore wind installations is to be made by Sweden and Finland, but with some capacity installations by all other countries. It is worth noting that during this period first installations are also to be made in Lithuania and Estonia / Latvia.

The results of offshore wind installation capacity forecast for the Baltic Sea indicate two distinct Commercial Operations Date (COD) volume peaks. The first one of ca. 12 GW is to take place in 2026 and 2027 and the second one of above 15 GW between 2029 and 2030. From foundation and turbine installation perspective however, these peaks may be smoothed to some degree as installation of first foundations will take place at least one or even two years earlier.

Additionally, based on the project pipeline, it is expected that in the Baltic Sea between the years 2022-2030:

a) Almost 2300 foundations and 2150 turbines will be installed;

b) Nearly 77% of the installed foundations will be structures classified in categories 2 and 3 (see Part 5), i.e. heavier than 2000 t;

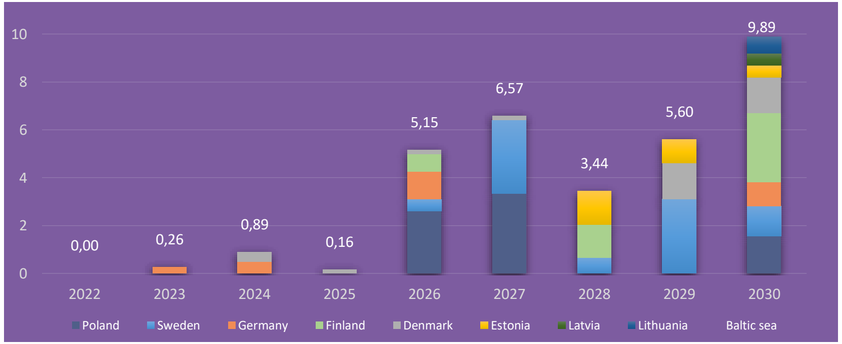
c) Circa 45% of the installed turbines will have a unit capacity greater than 15 MW (category 3 - see Part 4);

d) Approximately 4000 km of export cables and 4650 km of inter-array cables will be installed.

As the analysis has shown, further projects will be implemented after 2030, so the demand may further increase.

The following pages present details on the status and forecasts for Baltic Sea markets by country.

Figure 11 – New installations in the Baltic Sea region based on the COD date [GW]



Source: H-BLIX based on publicly available information, such as investor and project specific reports and websites.

IN GERMANY, THE NEW REGULATORY FRAMEWORK SUPPORTS REALIZATION OF AMBITIOUS OFFSHORE WIND TARGETS, WHICH CALL FOR 30 GW BY 2030.

Total, including pre-2022 installations **30 GW by 2030**

4 GW by 2030 Baltic Sea

Germany

In Germany at the end of 2021, 1501 offshore wind turbines with a total capacity of 7 794 MW were in operation, of which 1096 MW (14%) were installed in the Baltic Sea. In 2021, additional capacity was awarded in the tender rounds for installation in 2026. If all the awarded projects are commissioned, the total installed capacity at the end of 2026 will reach almost 12 GW. As shown in Figure 12, this includes projects with already made Final Investment Decision (FID) for 2,2 GW and awarded in tenders (grid connection commitments) for 1,9 GW [D5].

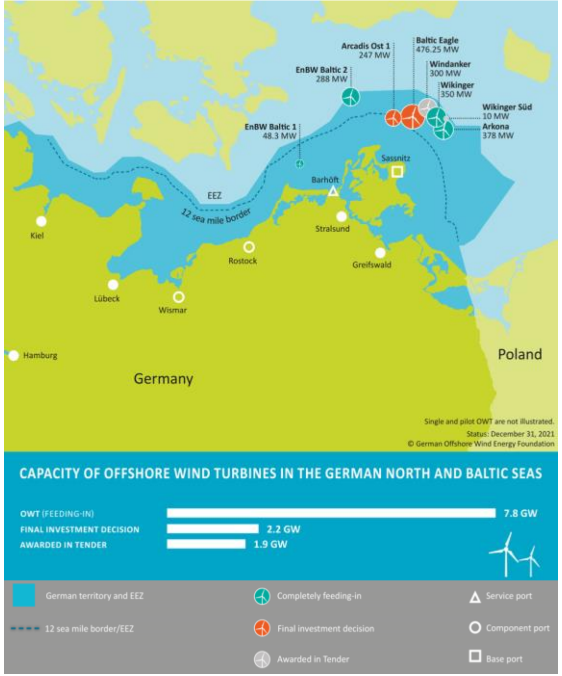
The so-called "Easter Package" (the biggest change to the country's energy policy legislation in years) adopted in April 2022, will significantly accelerate the development of offshore wind. The latest targets are 30 GW in 2030, 40 GW in 2035 and 70 GW in 2045. The legal framework was also amended to e.g. shorten the permitting process and intensify offshore wind energy in MSP. A new approach to site permitting is based on two equally important systems: auctions of sites that have already been pre-surveyed by state authorities and auctions of sites that have not yet been pre-developed. Centrally pre-developed areas would be auctioned based on price, awarding 20-year Contracts for Difference (CfDs). Not centrally pre-developed areas will be auctioned according to a catalogue of criteria which would also include qualitative ones. The "Easter Package" is not the last legislative change for wind energy in this political term. The German government announced "Summer Package", which will include: a national repowering strategy, new measures to ensure sufficient sites for offshore wind farms (OWFs), improvements to permitting and a new strategy to harmonize the expansion of wind energy with biodiversity and nature protection [N1]. Considering the above H-BLIX forecast, presented in Table 4 below, has very good chances of realization. It is also estimated that almost 3 GW could be commissioned in the German part of the Baltic Sea by 2030, of which 1,033 GW are projects already awarded in tenders with planned commissioning by 2026 (projects: Arcadis Ost 1, Baltic Eagle and Windanker). Additionally, the H-BLIX forecast includes the Gennaker project in the costal waters and potential new developments of 1 GW in offshore wind dedicated areas in the Baltic Sea by 2030.

Table 4 – New installations in Germany based on COD [GW]

Germany	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total 2022 - 2030
Baltic + North Sea	0,00	0,26	0,48	1,80	1,17	1,80	1,80	7,40	7,40	22,1
Baltic Sea	0,00	0,26	0,48	0,00	1,17	0,00	0,00	0,00	1,00	2,9

Source: Source: H-BLIX based on GWEC 2021 [D1], WindEurope and publicly available information, such as investor and project specific reports and websites.

Figure 12 – Offshore Wind Energy Map



Source: German Offshore Wind Energy Foundation [S1].

DEVELOPMENT OF OFFSHORE WIND IN FINLAND IS AT THE BEGINNING OF THE PROCESS. HOWEVER, FINLAND MAY COMMISSION AS MUCH AS 5 GW BY 2030.

Total, including pre-2022 installations **5,1 GW by 2030**

Finland

Onshore wind is already well established as a source of electricity in Finland. In the case of offshore energy, however, at the end of 2021, there were only 19 wind turbines connected to the Finnish electricity grid within three farms with a total capacity of 71 MW.

The construction of OWFs on market terms has not been profitable in Finland so far, and due to the lack of a clear support system and government programs, the development of offshore wind energy has not been as dynamic as for example in Germany. Nevertheless, in new geopolitical situation, offshore wind is expected to become important, especially that the country presents significant offshore wind potential, which was estimated in BEMIP, 2019 [D4] to be 8 GW.

Currently for offshore wind, the permitting procedure and the issuing authority differ depending on the project location (EEZ vs territorial sea). In the EEZ the competent authority is the Ministry of Labor and Economy. The MSP does include OWF areas, but developers may also select different sites to be investigated. In order to execute a project, it is necessary to obtain governmental approval, and an opinion of the Armed Forces, which is crucial from project development point of view.

In territorial waters, OWFs require, among others, a zoning plan that permits the construction of wind farms, as well as building permits, just as in case of onshore wind farms. Territorial waters belong to individual municipalities according to territorial extent. The administrator and lessor of the territorial water areas is the state enterprise Metsähallitus. Leasing of marine areas managed by Metsähallitus is carried out based on reservation and concession agreements. Reservation agreements are granted only for areas dedicated to offshore wind energy in provincial spatial development plans. Currently, almost all permitted areas have reservation agreements (non-exclusive) [D8, N6], which shows an interest in offshore wind.

In December 2021, a proposal for an auction model was approved in which the Metsähallitus Administrator will select, in designated 3-4 territorial sea areas (excluding Åland province and the EEZ), the entities that will have the right to develop a project within a certain time period [N7].

Metsähallitus is also a developer of one of the largest projects under development, the Korsnäs OWF, with a planned capacity of 1,3 GW, located 15 km off the west coast of Finland. The selection of a partner for the project has now started and is expected to be completed in 2022.

In addition, in early 2022, the government granted the first three research permits for projects in Finland's EEZ (two in the same area) with a total estimated capacity of 3,8 GW [N5].

Considering the above and other identified development projects in Finland, including Pori Tahkoluoto Extension (720 MW), as well as competitive nature of some projects being proposed in the same area, H-BLIX predicts that the country may commission ca. 5 GW by 2030 (Table 5 below).

In addition, on 18th January 2022, the Finish Minister of Finance, Minister of Environment and Climate Change, and Minister of Economic Affairs announced the development of proposals for financial solutions to accelerate the country's green transformation [N4], which may also support offshore wind farm development.

Table 5 – New installations in Finland based on COD [GW]

2022	2023	2024	2025	2026	2027	2028	2029	2030	Total 2022 - 2030
0,00	0,00	0,00	0,00	0,72	0,00	1,40	0,00	2,88	5,00

Source: H-BLIX based on publicly available information, such as investor and project specific reports and websites.

DUE TO VERY SPECIFIC REGULATIONS SWEDEN HAS A NUMBER OF COMPETING PROJECTS UNDER DEVELOPMENT, WHICH ARE EXPECTED TO TRANSLATE TO CA. 8-9 GW BY 2030.

Sweden

Total, including pre-2022 installations **8,7 GW by 2030**

In Sweden the last offshore wind farm was commissioned in 2013 and currently the installed capacity is 192 MW. The development of offshore wind should however accelerate significantly in the next few years. Currently, there is about 100 GW of competing offshore wind projects under development, applying for relevant permits through a complex permitting process. As presented in Figure 13, Sweden has three MSPs in the EEZ for: Gulf of Bothnia, Baltic Sea, Skagerrak/Kattegat. However, these plans are not legally binding.

According to data from the Swedish Wind Energy Association, projects with an annual energy production of approximately 174 TWh are at an early stage, before consultations, which in the most optimistic scenario could result in their commissioning after 2032. Another 125 TWh are in the consultation and preparation phase, which translates into possible commissioning in 2029 at the earliest. The most advanced are projects with a potential production of about 67 TWh (approx. 17 GW installed capacity), which are in the process of permit review. It is estimated that the winning projects could be commissioned in about 6 years time [N8]. Some of the mentioned projects are already based on floating foundations.

Considering very many competing projects, being frequently developed over the same or similar areas, only the most advanced ones, with clear schedule, were considered as part of the forecast presented in Table 6 below.

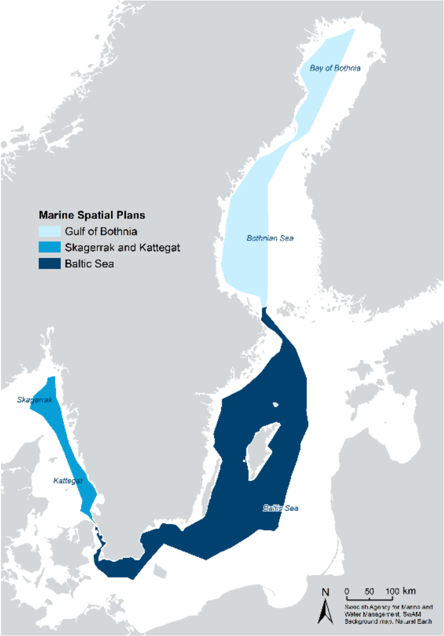
Table 6 – New installations in Sweden based on COD [GW]

2022	2023	2024	2025	2026	2027	2028	2029	2030	Total 2022 - 2030
0,00	0,00	0,00	0,00	0,50	3,06	0,64	3,10	1,25	8,55

Source: H-BLIX based on publicly available information, such as investor and project specific reports and websites.

In recent months, the Swedish government has focused on accelerating offshore wind development, including Sweden's first offshore plans. These however may have limited or no impact on the capacity to be installed in 2030 perspective.

Figure 13 – Sweden's three marine planning areas



Source: The Swedish Agency for Marine and Water Management [S4]

DENMARK PLANS TO COMMISSION ALMOST 4 GW IN THE BALTIC SEA BETWEEN 2022-2030. LITHUANIA WILL HAVE THEIR FIRST OFFSHORE WIND FARM OF 700 MW BY 2030.

0,7 GW by 2030

Denmark

Total, including pre-2022 installations: 10,6 GW by 2030

Baltic Sea: 5,4 GW by 2030

Denmark is the most experienced country in offshore wind energy with the first OWF commissioned in 1991. Currently, the installed capacity is 2,3 GW (of which 1,5 GW in the Baltic Sea) with several projects under development. The energy policy, reflected in the Esbjerg Declaration [D15], is to reach at least 10 GW by 2030.

The legal framework for offshore wind energy in Denmark is transparent and proven. Location permits are obtained through both an open-door formula and a bidding process. The OWFs established through an open-door procedure can cover areas which have not been designated for OWF. The tendered OWFs cover areas elected by the State based on their potential for wind energy, balanced against impact on the nature and environment [D6].

As presented in Table 7 below, by 2024 two projects with a total capacity of ca. 410 MW (Aflandshage and Nordre Flint projects) have been identified in the Danish Baltic Sea project pipeline. The Danish government and the Danish TSO (Energinet) expect 500 MW between 2025 and 2027 in an open-door formula for the Baltic Sea [D7].

The Danish Climate Agreement for Energy and Industry 2020 includes the creation of two energy islands of 3 GW and 2 GW in the North Sea and Bornholm, respectively. The energy island in the Baltic Sea (Bornholm) is assumed to be fully commissioned in 2030. As the location of further wind farms is not yet known, the above agreement assumes also additional 2 GW to be spread evenly between the North Sea and the Baltic Sea with expected commissioning in 2029 and 2030 [D7].

Table 7 – New installations in Denmark based on COD [GW]

Denmark	2022	2023	2024	2025	2026	2027	2028	2029	2030	SUM*
Baltic + North Sea	0,10	0,02	0,41	0,16	0,62	2,00	1,00	2,00	2,00	8,31
Baltic Sea	0,00	0,00	0,41	0,16	0,17	0,17	0,00	1,50	1,50	3,91

Source: H-BLIX based on GWEC 2021 [D1], WindEurope and publicly available information, such as investor and project specific reports and websites. *Total 2022 - 2030

Lithuania

In the "National Energy and Climate Action Plan of the Republic of Lithuania for 2021-2030“ published in 2019, 700 MW of installed offshore wind capacity is predicted by 2030, but current political discussions aim even at 1400 MW by that time.

Some of the required regulations are in place. In June 2020 a Government Resolution was adopted to build and start operation of the first 700 MW offshore wind park by 2030 with a tender planned for 2023. In September 2021 Lithuania has adopted its new Comprehensive Plan that includes MSP (the MSP presents a large offshore wind development area (~3,4 GW) and two other suitable smaller areas (<1 GW)). At the end of March 2022, the Lithuanian parliament adopted the Law on Energy from Renewable Sources, which regulates support scheme for offshore wind parks.

The permitting procedure for offshore wind projects in Lithuania are clear and straightforward. Projects, with no more capacity than in the government order, can only be developed in areas designated by the government by obtaining a development and operation permit on a contest (tender / auction) basis - valid for 41 years.

Currently, Lithuania has only one project in the pipeline. The permit and the subsidy for this project with a capacity of 700 MW will be auctioned by the government in 2023. The project should be commissioned in 2030 (Table 8). The specific coordinates of this project lie within the area from the MSP with a possible capacity of up to 3,4 GW. A detailed information regarding project area is expected to be available to the developers before the auction in 2023. The Lithuanian government has already selected contractors for EIA, hydrological-meteorological and seabed studies [N3].

Table 8 – New installations in Lithuania based on COD [GW]

2022	2023	2024	2025	2026	2027	2028	2029	2030	Total 2022 - 2030
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,70	0,70

Source: H-BLIX based on publicly available information, such as investor and project specific reports and websites.

ESTONIA PLANS TO COMMISSION ALMOST 3 GW BY 2030 WITH A NUMBER OF PROJECTS HAVING COD AFTER THIS DATE. LATVIA IS FOCUSING ON THEIR ONSHORE RESOURCES.

Estonia

2,9 GW by 2030

Estonia currently has no specific targets for offshore wind energy in its policies and strategies. Estonian government declares however high ambitions regarding renewable energy projects, including offshore wind. In May 2022 Estonia has adopted MSP, which provides a basis for the submission of seabed permit applications / counter applications and the execution of priced based competitive procedures for offshore wind sites. Wind farms in these sites will most likely be commissioned post 2030.

Considering the above, three projects were identified as having a potential to be commissioned by 2030 with a total capacity of 2,9 GW (Table 9). These are:

- A project of Saare Wind Energy and Van Oord (1400 MW, COD in 2028);
- A Liivi Bay project (1000 MW, COD in 2029) being developed by Esti Energia and Ørsted;
- An ELWIND project being developed jointly by Estonia and Latvia (total capacity 1000 MW split equally between the partners, COD in 2030).

In addition, in April 2022, Enefit Green announced the preparation of a preliminary design for the Hiiumaa offshore wind farm and the start of the construction process before 2030. It is unlikely however, that the project will have a COD in this decade.

Table 9 – New installations in Estonia based on COD [GW]

2022	2023	2024	2025	2026	2027	2028	2029	2030	Total 2022 - 2030
0,00	0,00	0,00	0,00	0,00	0,00	1,40	1,00	0,50	2,90

Source: H-BLIX based on publicly available information, such as investor and project specific reports and websites.

Latvia

0,5 GW by 2030

"Latvia's National Energy and Climate Plan 2021 – 2030" (NECP) published in 2020 presents basic principles, goals and actions for the long-term planning of energy and climate policy. In the NECP 800 MW of wind energy capacity is foreseen by 2030, but for economic reasons the aim is to use all onshore wind potential first. Offshore wind will be up for development at a later stage, although the country presents significant offshore wind potential, which was estimated to be 14,5 GW in Study on Baltic offshore wind energy cooperation under BEMIP [D4].

In September 2020 Estonia and Latvia signed an MoU for a joint offshore wind project to be developed within the Estonian EEZ (ELWIND). Total capacity of 1000 MW for this project is considered by Latvia to be sufficient to meet country's expectations.

In March 2022, the Latvian Government rejected an application from Ørsted and Eesti Energia for the development an offshore wind farm in Latvian waters [N2].

For the purpose of the demand analysis for Latvia 500 MW was considered, being 50% of ELWIND project capacity (Table 10).

Table 10 – New installations in Latvia based on COD [GW]

2022	2023	2024	2025	2026	2027	2028	2029	2030	Total 2022 - 2030
0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,50

Source: H-BLIX based on publicly available information, such as investor and project specific reports and websites.

DESPITE THE CURRENT POLICY TARGET OF JUST 5,9 GW, POLAND MAY COMMISSION ALMOST 7,5 GW BY 2030.

7,5 GW by 2030

Poland

Poland has significant potential for the development of offshore wind. In line with WindEurope study [D10], the total potential of the Polish part of the Baltic Sea could be 28 GW by 2050, which is about one-third of the total potential of the Baltic Sea (83 GW). According to Polish Energy Policy 2040, Poland is going to install 5,9 GW by 2030 and 11 GW by 2040. These figures however are very likely to be revised upwards in a near future.

Thanks to the adoption of the Offshore Wind Act (February 2021) and the MSP (April 2021) the development of the Polish offshore wind market gained significant momentum. Currently, 8 projects (presented as Wave I in Figure 14) with a capacity of ca. 5,9 GW secured contracts-for-difference (CfDs), granted by the Polish Energy Regulatory Office (ERO) as part of an administrative procedure, introduced by the Offshore Wind Act.

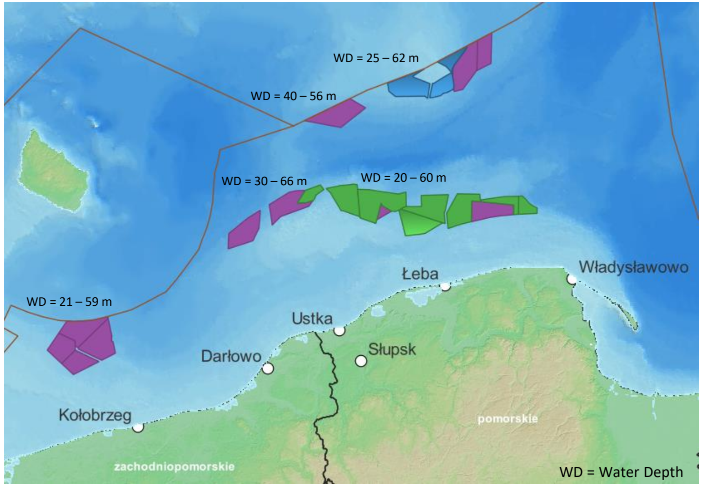
In addition to the above, there are two less advanced projects on the Polish – Swedish border with a total capacity of just less than 2,5 GW.

The Offshore Wind Act also formed a foundation for starting the second wave of seabed permit applications for 11 new sites (Figure 14) with a total capacity of ca. 8,8 GW. With 132 applications filed [N14], the sites received significant interest from both local and international players. Projects of the winning bidders, selected on the basis of the criteria presented in secondary regulation, may participate in auctions in 2025 and 2027 for which a total of 5 GW (2,5 GW each) was assigned in the Offshore Wind Act.

Considering publicly available information from investors regarding Wave I project schedules, discussions on the subject with selected developers as well as Wave II general project timeline developed by H-BLIX, Table 11, presents an envisaged timeline for commissioned capacity in the Polish EEZ by 2030 (5,9 GW of Wave I projects plus Bałtyk I project of 1,56 GW by 2030).

Details regarding the projects in the Polish EEZ, including their capacity and envisaged implementation timeline are presented on the next page.

Figure 14 – Ares designated for OWF in Polish EEZ



Legend: Wave I projects | Wave II projects with seabed permit | Wave II areas

Source: H-BLIX

Table 11 – New installations in Poland based on the COD date [GW]

2022	2023	2024	2025	2026	2027	2028	2029	2030	Total 2022 - 2030
0,00	0,00	0,00	0,00	2,60	3,34	0,00	0,00	1,56	7,49

Source: H-BLIX based on publicly available information, such as investor and project specific reports and websites.

WAVE I AND II ESTIMATED CAPACITY TO BE COMMISSIONED IN THE POLISH EEZ EXCEEDS 17 GW. 2,6 GW AND 3,3 ARE GOING TO BE COMMISSIONED IN 2026 AND 2027 RESPECTIVELY.

7,5 GW by 2030

Poland

Table 12 below summarizes Wave I projects in the Polish EEZ. The most advanced projects, mentioned in no particular order, are: Bałtyk II and Bałtyk III developed by Polenergia / Equinor, Baltica 3 and Baltica 2 developed by PGE / Ørsted, Baltic Power developed by PKN Orlen / Northland Power, FEW Baltic II developed by RWE and B-C Wind projects developed by Ocean Winds. In line with investors' declarations, the above projects should be commissioned between 2026 and 2027.

In Wave II (Table 13), only two projects have already obtained seabed permits. These are Bałtyk I, a third project of Polenergia / Equinor, which should be completed by 2030 and Baltica I (PGE) which is expected to be commissioned beyond 2030. Table 12 presents also 11 Wave II areas for which 132 applications have been filed by Polish local and international entities or their JVs. The total capacity of these areas may reach ca. 8,83 GW, which in turn makes a total of ca. 17 GW for the Polish EEZ. A detailed analysis of a schedule for these developments shows that considering the current regulations and practices, it is rather unlikely that any of them will be completed by 2030.

Table 12 – Polish Wave I projects

No.	Company	Project	Capacity [MW]	COD	Assumed turbine size [MW]
1	Polenergia / Equinor	Bałtyk II	720	2027	14+
2	Polenergia / Equinor	Bałtyk III	720	2027	14+
3	PGE / Ørsted	Baltica 2	1498	2027	14+
4	PGE / Ørsted	Baltica 3	1045	2026	14+
5	RWE	FEW Baltic II	350	2026	14+
6	PKN Orlen / NPI	Baltic Power	1200	2026	14+
7	Ocean Winds	B Wind	200	2027	14+
8	Ocean Winds	C Wind	200	2027	14+
Total for wave I			**5 933**		

Source: H-BLIX based on publicly available information, such as investor and project specific reports and websites.

Possible COD dates however are between 2031 and 2033, except for area 53.E.1, which has been imposed a construction restriction in the MSP beyond 2040.

Table 13 – Polish Wave II projects and designated areas

Project from Wave II with seabed permit							
No.	Company		Project	Capacity [MW]	COD	Assum. turbine size [MW]	
1	Polenergia / Equinor		Bałtyk I	1560	2030	18+	
2	PGE		Baltica 1	896	2031	18+	
Total				**2 456**			
Areas designated for Wave II							
No.	Area	Assumed Capacity [MW]*	Construction ** and commissioning	Assumed turbine size [MW]	Construction area [km2]	Depth [m]	Dist. to shore [km]
1	14.E.1	660	2031-2033	18+	82,4	21-33	29
2	14.E.2	730	2031-2033	18+	91,2	21,5-37	36
3	14.E.3	1007	2031-2033	18+	125,9	31-54,5	42
4	14.E.4	1182	2031-2033	18+	147,7	27-59	34
5	43.E.1	947	2031-2033	18+	118,4	33,5-66	48
6	44.E.1	970	2031-2033	18+	121,3	30-57	53
7	45.E.1	138	2031-2033	18+	17,2	27,5-40	34
8	46.E.1	895	2031-2033	18+	111,8	30-40	24
9	53.E.1	868	2040-2043	?	108,5	40-56	78
10	60.E.3	925	2031-2033	18+	115,6	34-58	83
11	60.E.4	510	2031-2033	18+	63,7	42-62	89
	Total	**8 830**					

Source: H-BLIX based on Polish MSP [D11], Polish ordinance related to offshore wind applications assessment criteria [D12], information from the SIPAM portal [S5], and other publicly available information.

*Based on construction area and density factor of 8 MW/km^2

** Construction – period of marine operations related to actual wind farm construction in the area of seabed permit

PART 3: Offshore wind trends

ONE OF THE KEY TRENDS IS AN INCREASE IN TURBINE SIZE, WHICH INFLUENCES MANY SITE AND PROJECT PARAMETERS, TOGETHER IMPACTING VESSEL SUITABILITY.

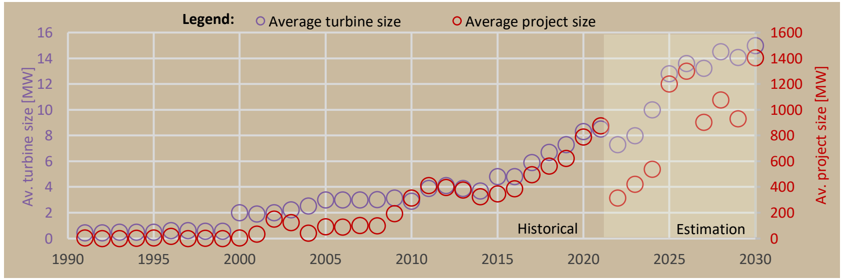
Introduction

Since its beginning in the 1990's, the offshore wind industry has been undergoing a constant change, gaining even more momentum over the last few years. The most important trends, which lead to significant reduction of LCOE, but also impact availability and suitability of installation vessels are presented below.

Turbine size, project size and distance to shore

One of the most important trends in the offshore wind industry, responsible to a large extent for the reduction of LCOE, is the increase in turbine size [D3]. As shown in Figure 15 below, throughout the 1990's an average turbine size was below 1 MW. The progress was made in 2000, which then slowly increased average turbine size to 2,9 MW in 2010. Since 2015 there has been a rapid increase in turbine sizes installed in offshore wind projects, with average of 8,5 MW in 2021 in Europe. In 2030, in Europe the average size of installed turbine is predicted to be 15 MW, so five times more than in 2010.

Figure 15 – Average turbine and OWF project size in Europe



Source: H-BLIX based on information from WindEurope.

Soon, 14-15 MW turbines will enter production at leading turbine manufacturers (e.g. SGRE, GERE, Vestas), with a view to be installed in projects with COD planned for 2025-2026. As shown in Table 14, one may expect that the next generation of 17-18 MW turbines may become available in 2027-2028. Saying this however one cannot exclude a technological leap with 20MW+ turbines available from for example 2030 onwards.

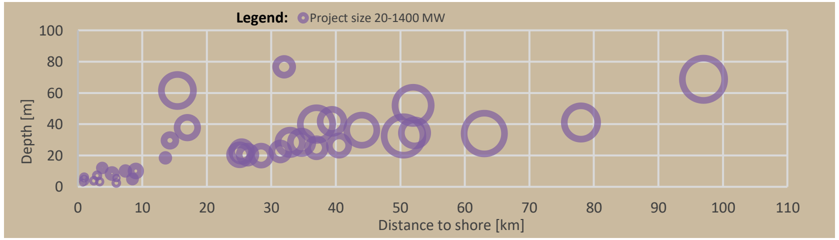
Table 14 – Current and forecasted offshore wind turbine parameters

	Largest currently installed WTGs	Largest WTGs in serial production soon	WTGs for 2027-2028	WTGs for 2030+
Capacity	6-9,5 MW	14-15 MW	17-18 MW	20 MW
Rotor diameter	150 – 164 m	222 - 236 m	240-250 m	250-300 m

Source: Manufacturers' data, own assumptions for 2027 and beyond based on performed interviews.

As presented in Figure 15, historically (1990 – 2020) there has been a very good correlation between average turbine size and offshore wind project size, which to some extent may continue into the future. According to WindEurope, the average project size in Europe in 2021 was 875 MW and is estimated to be around 1400 MW in 2030. As shown in Figure 16, project size is also correlated to some extent to water depth and distance to shore. As closer to shore and more convenient sites are already occupied, the industry is looking for suitable locations further from the coastline, which however may also have a greater water depth, which impact foundation size and hence vessel suitability.

Figure 16 – OWFs depths and distances to shore in Europe



Source: H-BLIX based on annual average data collected by WindEurope from OWF projects in Europe (1990-2030)

WITH THE INCREASE IN TURBINE SIZE, ONE MAY EXPECT SIGNIFICANT ENLARGEMENT OF FOUNDATIONS WITH WEIGHT OF CA. 3000T IN CASE OF MONOPILES.

Foundations

An increase in turbine size and water depth results in an enlargement of foundations being installed and may also influence their type. Increasing loads resulting from larger turbines and greater depths require deeper embedment and/or larger diameters to ensure structural rigidity. Recent predictions of 11,5 m diameter monopiles with the weight of ca. 2500 t have been replaced by much bolder forecasts of monopiles with 15 m bottom diameter, ca. 150 mm wall thickness and weight of ca. 3000 t, which have been mentioned in the recent 4C Offshore report [D9] and also result from the interviews made by H-BLIX as part of this report. With such large monopiles, however, two questions need to be addressed: project economics driven by recent steel price increase and noise intensity during installation, even considering the most advanced installation techniques.

Considering the above, currently is it difficult to predict the exact development direction and investor's preferences between monopiles and jackets. On one hand, monopiles are forecast to remain the preferred option, but their share may decrease at the expense of jacket foundations due to, amongst others, the increase in the average water depth of projects. On the other hand, industrialization of the production of monopiles and the demonstrated ability of the industry to adapt the foundations to deeper waters while maintaining low cost may allow monopiles to remain the dominant substructure type for some time or even increase market share [D3].

The choice of foundations and hence the specification of a required vessels will in the end be project specific. For example, for Wave I projects to be delivered in the Polish EEZ, on the basis of investor information, it is estimated that almost all projects will use monopiles. For Wave II projects, however, an initial analysis in which H-BLIX has been involved indicates that up to 50% of foundations may need to be jackets due to water depth, geological conditions or cost preference.

Floating wind

In the second half of this decade, floating offshore wind is expected to make its commercial introduction into the offshore wind market. Floating offshore wind's share in operating offshore wind capacity worldwide is forecasted to increase from 0,1% in 2021 towards 6,1% in 2030, ref. GWEC [D1]. Out of 16,5GW floating wind to be installed towards 2030, the majority is forecasted to be installed in 2028-2030, with 3,4 GW, 2,8 GW and 6,3 GW added capacity respectively accounting for approximately 10% of yearly added offshore wind capacity worldwide.

As floating wind is currently in its pre-commercial stage, a learning curve in general including for installation is expected over the coming years. Different types of floating foundations are expected to be implemented for projects worldwide, depending on local and project specific constraints such as amongst others environmental conditions, available infrastructure and supply chain. As such, also installation methodologies are expected to be project specific to a certain extend.

The majority of floating foundations is expected to be manufactured and/or assembled locally, nearby or in the marshalling port, as this is expected to be more efficient and cost effective than transportation of foundations in one piece. Most foundations are expected to be launched/lifted from a quayside without the need for FIV, to limit costs and remain independent from FIV availability. It is expected this will impact worldwide FIV demand towards the end of this decade to a certain extend.

Floating offshore wind turbines can be installed onto their foundation offshore, or in port followed by a tow-out to site. For offshore turbine installation, floating installation vessels and/or alternative installation equipment will be required. The majority of floating wind is expected to be installed in port, requiring a WTIV or suitable land crane (not easily available). The impact of floating wind on worldwide WTIV demand is expected to be limited.

For floating cable installation, most installations are expected to have dynamic power cables prepared and wet stored by CLV, after which they are pulled into their floating foundation by the vessel that connects the floater to its anchors. Although array cable installation time is expected to slightly reduce, limited impact on CLV demand worldwide is expected.

PART 4: Wind turbine installation vessels

WindEurope

POLISH WIND ENERGY ASSOCIATION

H-BLIX

REGIONAL TIES OF ASSETS ARE EXPECTED TO HAVE NO IMPACT ON AVAILABILITY ELSEWHERE. PHYSICALLY LIMITED ACCESS TO BALTIC SEA EXPECTED TO HAVE NO EFFECT ON WTIV AVAILABILITY.

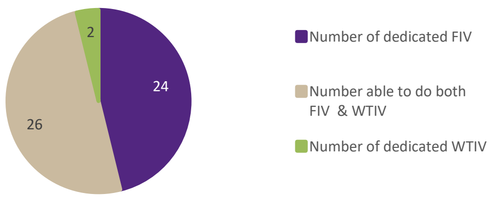
Turbine/foundation installation vessel type determination

The worldwide available vessels that can install or have been involved in installation of turbines and/or foundations have been identified and are presented in Appendix B (List of vessels). The majority of assets available worldwide that can install turbines, are also able to install foundations. Vice versa, some of the heavy lift assets (e.g. Heerema's Thialf) are able to install wind turbines or possibly will be in the future.

As shown in Figure 17, out of the identified number of vessels that can install wind turbines or foundations worldwide and are available in 2026, 26 can install both turbines and foundations, 2 are only suitable for turbine installation and 24 only for foundation installation.

With an equal amount of foundations and turbines to be installed, and in general a longer installation time for turbines, it is expected that assets able to install both foundations and turbines will mainly focus on the latter. In the analysis described in this report these 28 vessels are considered to be wind turbine installation vessels.

Figure 17 – Worldwide asset capability by 2026



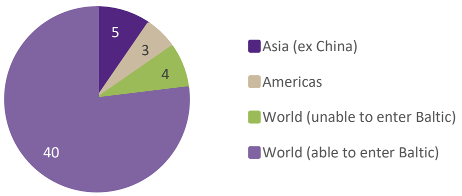
Source: H-BLIX

Worldwide turbine/foundation installation vessel regional allocation

Some regional offshore wind markets in the world - e.g. the USA and Japan - have legislation in place prohibiting foreign vessels to execute projects in their waters. In these markets the number of vessels compliant and allowed to work, is generally lower than the required number of vessels to install the set targets. The remainder of offshore wind projects will have to be installed by foreign installation vessels, avoiding the limitations by legal dispensation and/or a creative solution such as feeder barges. It is expected that location compliant vessels will not move out of their dedicated region to foreign markets, however, free market vessels might move to these restricted markets. As such, this is expected to have no effect on local free markets such as for example the Baltic Sea.

In 2026, looking at the Foundation Installation Vessels (FIV) and Wind Turbine Installation Vessels (WTIV) combined, 8 out of 52 assets are dedicated to Asia and the Americas. With limitations present in Denmark for the vessels' draft (Oresund) and height (Storebelt), assets have been assessed for their ability to enter the Baltic Sea. Out of 44 not tied to a specific market, only 4 foundation installation assets are unable to enter the Baltic Sea (Figure 18). As a result 40 worldwide vessels are free and able to enter the Baltic Sea.

Figure 18 – Regional allocation WTIV and FIV by 2026



Source: H-BLIX

WORLDWIDE WTIV FLEET SHOWS SIGNIFICANT AND CONFIRMED GROWTH UP TO 2026. AFTER 2026 GROWTH EXPECTED TO CONTINUE TO SOME EXTEND, BUT UNCONFIRMED.

Worldwide vessel supply

The 28 vessels of the global wind turbine installation fleet are divided into three categories based on their maximum hook height, in line with nacelle installation heights, as shown in Table 15. A detailed list of identified wind turbine installation vessels can be found in Appendix B.

Table 15 – Wind turbine asset categorisation

Wind turbine category	Size [MW]	Hub height [m]	Required installation hook height amsl [m]
Cat. 1	<12	130	145
Cat. 2	12-15	145	160
Cat. 3	15+	160	180

Source: H-BLIX

As shown in Figure 19, starting at 10 installation assets in 2021, a large increase in WTIV is expected towards 2026, following forecasted global vessel demand. Currently, there are no confirmed orders known for vessels delivered after 2026, which corresponds to a lead time of ~3-4 years for this type of vessels.

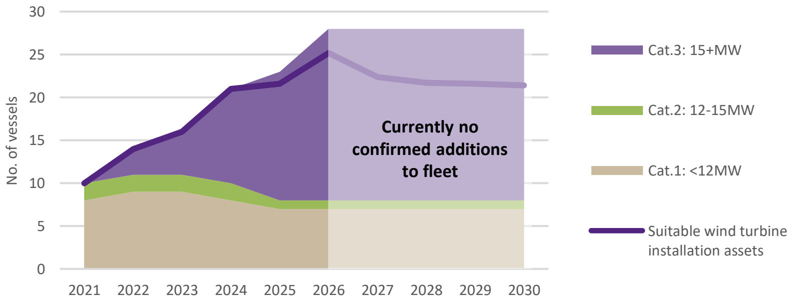
In the figure the total number of WTIV remains constant from 2026 onwards. It is expected that more vessels will be added to the global fleet also beyond 2026 in line with global demand, with fleet expansion depending on the market perspective and the expected return on investment for new vessel owners.

All but one of the fleet additions are Category 3 WTIVs with a hook height of more than 190 m, ready for the wind turbines of the future in line with the trends presented in the previous section of this report. Category 1 and 2 WTIVs show a decline in globally available vessels as some will take place in a higher category by upgrades that increase the crane lift capability of vessels (e.g. Cadelers Wind Osprey).

The number of suitable WTIVs shown in Figure 19 is defined per year, considering the required WTIV characteristics based on the expected wind turbine size. The number of suitable vessels is equal to the number of available vessels up to 2025. Due to ever increasing turbine sizes, as of 2025 and 2029 vessels of Category 1 and 2 respectively are expected to slowly become redundant as the turbine installation height exceeds their maximum hook height. As a result, the number of suitable installation vessels reduces.

For analysis purposes, a decline as of 2026 has been estimated based on forecasted data received from WindEurope and 4C Offshore [D9] and information gathered during interviews with offshore wind industry representatives.

Figure 19 – Worldwide wind turbine installation fleet up to 2030



Source: H-BLIX

IN TERMS OF GW INSTALLED PER VESSEL PER YEAR, WIND TURBINE INSTALLATION EFFICIENCY INCREASES SIGNIFICANTLY TOWARDS 2030.

Productivity calculation

For analysis purposes it is assumed that turbines are installed in the year of the targeted annual added capacity. Table 16 shows the pipeline of turbine installation projects used for the WTIV supply vs demand analysis. The pipeline has been calculated on the basis of predicted annual capacity to be installed (see Part 2 for details) and the average turbine size. As shown in Table 16, the number of turbines to be installed annually increases from 500 in 2022 to 2707 in 2030 worldwide.

The number of required WTIV has been calculated on the basis of the productivity of the average WTIV installing average size projects, expressed in [GW/v/y]. The average size project corresponds to the forecasted average project size [GW] determining the number of projects in that year, and turbine size [MW] determining the number of turbines to be installed per project.

As shown in Table 17, the average number of projects executed per WTIV per year is expected to slightly reduce towards 2030. As projects become larger and require an increased number of installation days, on average less projects will be executed per vessel per year.

The clean average installation time per turbine is determined taking into account round trips for loading a new batch of turbines in the marshalling port. An increase in efficiency of 10% towards 2030 is estimated due to technological advancement, such as e.g. turbine feeders.

The real average installation time includes clean avg. installation time plus all other project effects such as mobilization and demobilization, transit to project site, waiting on weather, maintenance, (logistical) inefficiency, etc. Here, efficiency gained as a result of larger project size can be seen, as relatively less time will be spent on project effects such as mobilization & demobilization, transit to project site, etc.

Installation times are estimated based on H-BLIX's project portfolio, benchmarked with information from 4C Offshore [D9] and historical project installation data provided by WindEurope.

The worldwide average installation capacity per vessel per year increases significantly from 0,5 GW in 2021 to 1,3 GW in 2030, due to a combination of increased turbine size, increased number of turbines per project and an estimated increase in installation efficiency.

Table 16 – Worldwide turbine pipeline

World ex China	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Cum.
Avg. project size [GW]	0,40	0,49	0,58	0,67	0,76	0,84	0,93	1,02	1,11	1,20	-
Avg. turbine size [GW]	8,2	9,1	10,0	10,9	11,8	12,7	13,6	14,5	15,4	16,3	-
No of projects [-]	11	9	18	22	28	31	26	24	34	37	240
No of turbines [-]	513	500	1043	1337	1816	2075	1764	1706	2481	2707	16k

Source: H-BLIX based on 4C Offshore [D9] and WindEurope

Table 17 – WTIV production figures used for analysis

WTIV productivity	2021	2030
Avg. installation capacity [GW / v / y]	**0,50**	**1,31**
Avg. number of projects per year / v / y	1,3	1,1
Avg. no of turbines / v / y	61	80
Avg. no of days in operation / v / y	229	251
Clean avg. install. time - days/turbine (incl. loading and transit to & from port)	1,8	1,6
Real avg. install. time - days/turbine (incl. loading and transit to & from port + all other project effects)	3,7	3,1
Maximum number of working days / y	300	300

Source: H-BLIX

WORLDWIDE WTIV SHORTAGE ALREADY EXPECTED IN 2025 AND 2026, WHICH MAY RESULT IN DELAY OF PROJECTS. BALTIC SEA MAY FACE UNDERSUPPLY UP TO NON-AVAILABILITY OF ASSETS

Supply vs demand – World and Baltic Sea

In Figure 20, the green line shows the supply in terms of number of suitable WTIV, as described on page 38. The worldwide WTIV demand per region is determined based on the forecasted yearly added capacity per region as presented in Part 2, and on the installation capacity in GW/vessel/year as described on the previous page.

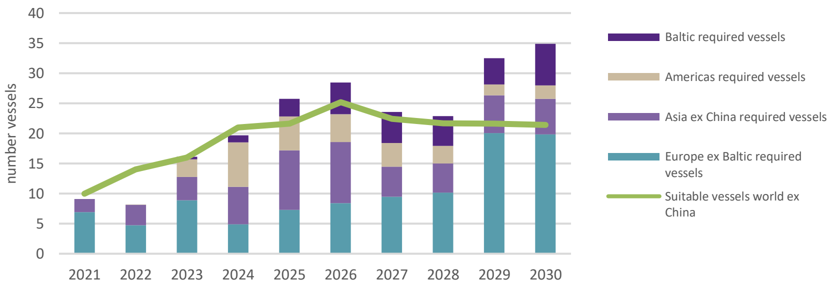
From 2025 onwards, the vessel demand exceeds worldwide available and suitable installation vessels. From 2025 to 2030, on average 28 vessels are expected to be required to ensure development of targeted capacity. For the Baltic Sea specifically an average of 5 vessels is estimated to be required over this period.

Without new additions to the fleet, starting from 2025 the market would be unable to install 3,2 GW per year, due to an average gap of 3,7 WTIVs over years 2025 to 2026. In 2029 and 2030 the market could even miss installation of 14,9 GW capacity per year, due to an average gap of 12,2 WTIVs over 2029 to 2030.

The gap in 2025 and 2026 will be difficult to bridge as it is nearby in relation to the lead time for new WTIVs. For the peaks in 2029/2030, there is still sufficient time to build the required amount of new vessels.

It is expected the peaks in demand, including those in 2025 and 2026, will flatten to a certain extend, with projects being delayed due to a difference between the worldwide targets and local / regional execution of planning. Delays may be caused by e.g. local governments being unable to facilitate development in time, lawsuits related to public appeals, unavailability of installation assets, other supply chain issues, etc.

Figure 20 – WTIV demand versus supply



Source: H-BLIX

For developments in the Baltic Sea as is the case for any development worldwide, the shortage is a risk to planned project execution. In some years Baltic Sea project developments risk having insufficient or worst case no installation asset at their disposal, under influence of market dynamics such as contractors' preferences or early asset reservation elsewhere.

To ensure in time installation of set targets, new additions to the fleet are crucial. For investors and new ship owners to purchase new additions to the fleet, it is key for (local) governments facilitate a stable offshore wind market outlook. This requires governments to ensure the right market conditions in terms of legislation and funding, and also to facilitate sufficient growth along the entire supply chain and required infrastructure.

THE BALTIC SEA REQUIRES SIGNIFICANT PART OF THE WORLDWIDE FLEET. DEMAND COULD BE REDUCED THROUGH COOPERATION. IN REALITY HOWEVER, LITTLE OPTIMIZATION IS EXPECTED.

Detailed study for Baltic Sea and Poland

Looking into the details for the Baltic Sea and Poland, based on a concrete project pipeline as described in Part 2, an upper and lower boundary of required vessels has been determined. Up to 9 and 13 WTIV in 2026 and 2030 respectively are expected to be required to ensure development of predicted capacity in the Baltic Sea. As shown in Figure 21, Poland's significant share of capacity to be installed in the Baltic Sea is reflected in the annual demand for up to 3 WTIVs between 2025 and 2027.

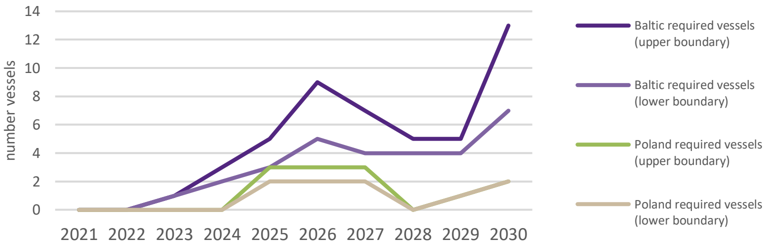
Considering vessel demand for the Baltic Sea, analysis presented in Figure 21 indicates that it could be reduced significantly if contractors and project developers work together to maximize vessel occupancy by means of cooperation amongst each other. In such a case, for example in 2026, the required number of vessels would drop from 9 to 5, and in 2030 from 13 to 7. Such a cooperation has been also identified as a trend by WindEurope [D14] to optimize maximum vessel working time, especially for neighboring projects.

For Poland alone a certain level of optimization is expected until 2027. From 2028 to 2030, as shown in Figure 21, limited optimization in vessel demand can be achieved, which is related to the Polish projects being of a size such that no synergies within Poland alone are possible. In reality, cooperation between developments in Poland and other countries in the Baltic, or rescheduled projects could however still allow for some optimization.

H-BLIX expect that, although some synergies and optimization opportunities will be realized by the supply chain, the resulting vessel demand could still be towards the upper boundary, as contractors will hesitate to fully book their vessels up front, as it introduces a risk of knock-on effects.

In reality peaks are expected to flatten with projects being delayed due to difference between the worldwide targets and local / regional execution of planning, be it because countries are unable to facilitate development in time, assets are not available, there are other delays in the supply chain, etc.

Figure 21 – Upper and lower boundary for required WTIV in Baltic Sea and Poland



Source: H-BLIX

PART 5: Foundation installation vessels

WindEurope
POLISH WIND ENERGY ASSOCIATION
H-BLIX

SIGNIFICANT GROWTH OF FOUNDATION INSTALLATION VESSEL FLEET WORLDWIDE UP TO 2026. AFTER 2026 COMMITMENTS EXPECTED BUT CURRENTLY UNKNOWN.

Worldwide vessel supply

H-BLIX has analyzed worldwide availability of foundation installation vessels (FIV) (formerly) active in offshore wind. A detailed list of identified FIV can be found in Appendix B. Some of these assets are dedicated to the installation of offshore wind farms, however the majority are also used to execute projects in other industries such as oil and gas.

For analysis purposes, future offshore wind foundations have been divided into three weight categories depending on their type and water depth as well as turbine size, as shown in Table 18:

- **Category 1** – 1500 t (monopile shallow and jacket deep, both for 14-15 MW turbine);
- **Category 2** – 2000 t (monopile shallow for 18-20 MW turbine, monopile deep for 14-15 MW turbine, etc.);
- **Category 3** – 2500 t (monopile deep and jacket ultra deep, both for 18-20 MW turbine).

While some analyses show that foundation weights may increase to 3500 t and larger, for a worldwide estimate up to 2030, H-BLIX considers such large foundations to be an exemption and expects that the majority of them will be in the range shown in the table below.

Table 18 – Foundation categorization

Turbine	14 -15 MW	18 - 20 MW
Found. type	Weight [t]	Weight [t]
Monopile shallow	1500	2000
Monopile deep	2000	2500
Jacket deep	1500	2000
Jacket ultra deep	2000	2500

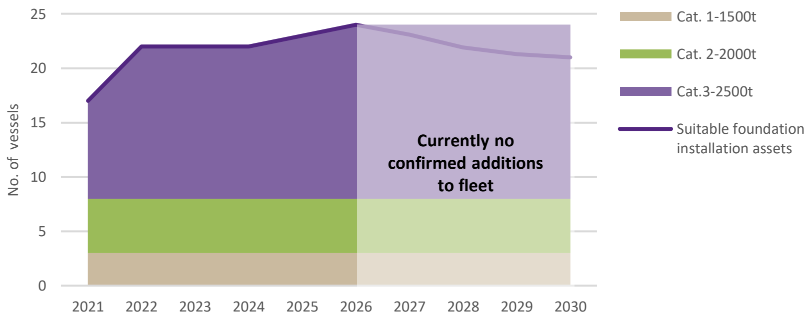
Source: H-Blix

The fleet has been divided into the same three categories based on their maximum lifting capacity at 30 m crane radius, as shown in Figure 22. At the end of 2021 the worldwide fleet of foundation installation assets consisted of 17 vessels. As in 2022 as many as 5 vessels are to be commissioned, the total number is to reach 22. This figure is to increase to 24 by the end of 2026. The 7 new assets are all floating installation vessels, such as e.g. the Green Jade.

With lead times of ca. 4 years, new builds after 2026 are currently unknown or unconfirmed. In case no new builds are added to the fleet after 2026, a decline in a number of suitable installation vessels will occur, as foundation sizes continue to increase and consequently vessels of category 1 and 2 are expected to become obsolete.

Regional allocation is considered to have no impact on the worldwide market, as presented in Part 4 of the report.

Figure 22 – Worldwide FIV fleet up to 2030



Source: H-Blix

SIGNIFICANT INCREASE IN THE NUMBER OF FOUNDATIONS TO BE INSTALLED BETWEEN 2022-2030 IS BALANCED BY A SIGNIFICANT INCREASE IN PRODUCTIVITY IN TERMS OF GW/VESSEL/YEAR

Productivity calculation

The number of required FIV has been calculated on the basis of the productivity of an average FIV, installing average size projects, expressed in [GW/v/y]. The average size project corresponds to the forecasted average project size [GW] determining the number of projects, and turbine size [MW] determining the number of foundations to be installed per project.

Table 19 below presents the number and size of the average size project towards 2030. It has been assumed that foundations are installed one year prior turbines. It can be seen the number of projects and foundations to be installed yearly increases significantly, from 18 projects with 1043 foundations in 2022 to 40 projects and 2982 foundations in 2030.

Table 19 – Worldwide foundation pipeline

World ex China	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Cum.
Avg. project size [GW]	0,49	0,58	0,67	0,76	0,84	0,93	1,02	1,11	1,20	1,29	-
Avg. turbine size [GW]	9,1	10,0	10,9	11,8	12,7	13,6	14,5	15,4	16,3	17,2	-
No of projects [-]	9	18	22	28	31	26	24	34	37	40	270
No of foundations [-]	500	1043	1337	1816	2075	1764	1706	2481	2707	2982	18k

Source: H-BLIX based on 4C Offshore [D9] and WindEurope.

The average FIV installation capacity and productivity figures are presented in Table 20. Oil and gas occupation for the identified vessels has not been taken into account. From this table it can be seen that the installation capacity increases significantly from an average of 0,63 GW/v/y in 2021 to 1,51 GW/v/y in 2030, mainly due to increasing project and turbine size as well as due to expected increase in installation efficiency. Towards 2030, the number of projects installed per vessel per year reduces slightly from 1,3 to 1,2, while the number of foundations installed per year increases significantly from 69 to 89. This is explained by the increasing size of projects and thereby increased installation time per project, resulting in less vessels executing multiple projects in one year.

The clean average installation time per foundation has been calculated with a weighted average of installation time for jackets and monopiles, taking into account an expected monopile market share of 80% up to 2030, as found from interviews and 4C Offshore [D9].

The real installation time per foundation includes all project effects as explained in Part 4. It can be seen that installation efficiency increase towards 2030, mainly because monopile installation is assumed to become significantly more efficient due to expected market entry of floating installation assets, able to bring more foundations. This will reduce transit time (e.g. Alfa Lift), even though the effect will be slightly damped by increased sizes of foundations. The installation time has been benchmarked with data from WindEurope and 4C Offshore [D9].

Table 20 – FIV production figures used in analysis

FIV production	2021	2030
Avg. installation capacity [GW / v / y]	**0,63**	**1,51**
Avg. number of projects per year / v / y	1,3	1,2
Avg. no of foundation / v / y	69	89
Avg. no of days in operation / v / y	210	210
Clean avg. install. time - days/foundation (incl. loading and transit to port)	1,5	1,2
Real avg. install. time - days/foundation (incl. loading and transit to port + all other project effects)	3,0	2,3
Maximum number of working days / y	280	280

Source: H-BLIX

* estimated 300 days reduced with 20 days for OSS installation, as described in Part 6

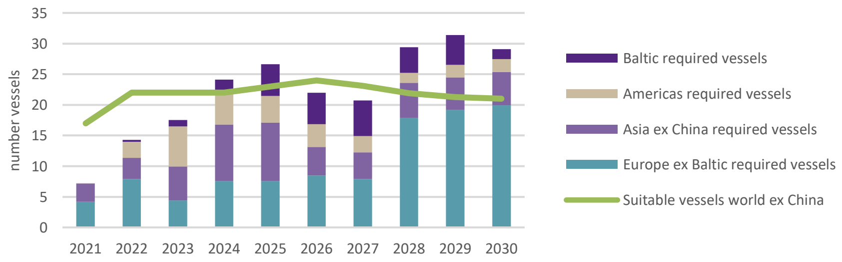
WORLDWIDE FIV SHORTAGE ALREADY EXPECTED IN 2024 AND 2025, WHICH MAY RESULT IN DELAY OF PROJECTS. BALTIC SEA MAY FACE UNDERSUPPLY UP TO NON-AVAILABILITY OF ASSETS

Supply vs demand - World and Baltic Sea

Considering Figure 23, from 2024 onwards there is a shortage in FIV. Without new additions to the fleet, already in 2024 and 2025 a shortage of 2,3 and 3,8 installation vessels is expected, resulting in an inability to install 2,0 and 3,8 GW of offshore wind capacity. In the years 2026 and 2027 globally there is an oversupply of installation vessels. From 2028 onwards the shortage increases significantly, and the offshore wind market could miss installation of 12 GW capacity per year due to an average gap of 8,8 FIVs from 2028 to 2030. As the gap of 2,3 FIVs in 2024 is earlier than new vessels can be delivered (based on an expected lead time of 3 to 4 years) lagging targeted installed capacity seems a realistic scenario. Postponing projects from 2024-2025 however does not solve the undersupply: over years 2024-2027 on average there is a shortage of 0,5 installation vessels.

As part of identified FIV also executes oil and gas projects, an increase in oil and gas prices will result in part of the FIV fleets operational time spent outside the wind industry, reducing installation capacity for offshore wind farms. Analyzing foundation installation vessels supply vs demand, this (potential) occupation outside of the wind industry has not been taken into account, meaning shortages could increase even further. A slight reduction in FIV demand is expected towards the end of this decade due to part of offshore wind developments being floating wind not requiring FIVs.

Figure 23 – FIV demand versus supply - worldwide



Source: H-BLIX

The expected global shortage of FIVs is a serious risk for the realization of planned offshore wind projects in the Baltic Sea, but also worldwide. Market dynamics, such as the preference for certain contractors or the early reservation of vessels elsewhere, can lead to projects in the Baltic Sea having insufficient or even no installation assets at their disposal when necessary. The same key mitigations apply as described in Part 4.

IN THE BALTIC SEA, ON AVERAGE 3 TO 6 FOUNDATION INSTALLATION VESSELS MAY BE NEEDED YEARLY BETWEEN 2024 AND 2030, OF WHICH ALMOST 40% WILL BE COVERED BY POLAND.

Demand - Baltic Sea and Poland

As in case of turbine installation, for the Baltic Sea and Poland, based on project pipeline presented in Part 2, an upper and lower boundary of required vessels have been determined. The four assets that cannot enter the Baltic Sea are expected to have no or limited market share in the installation of offshore wind foundations and thus their absence is expected to be negligible.

For the Polish demand analysis, constraints presented in the already issued EIA decisions have been taken into account for each project. Implications include a limitation of the foundation installation window for some projects, to between May and September or May and October. For one project (Baltic Power), winter installation has been allowed. The analysis has not taken into account a potential constraint limiting the number of foundation pilings in the Baltic Sea to two at any given time, which may require specific coordination of activities to limit the impact on installation progress.

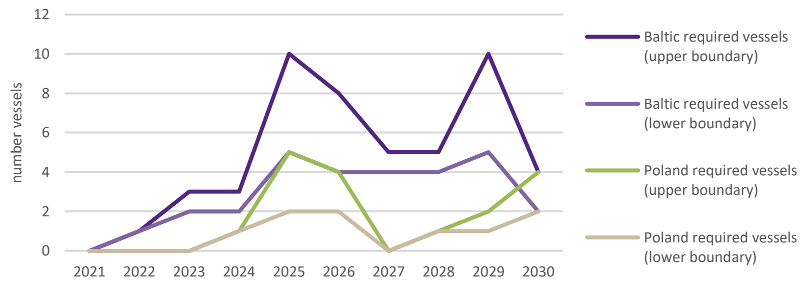
As presented in Figure 24, a significant number of FIVs is required to ensure the development of targeted offshore wind capacities in the Baltic Sea. Without any cooperation between developers and vessel operators within the Baltic Sea, almost half of the worldwide available installation resources would be required to enter the Baltic Sea for the execution of projects in 2025 (10 from 23 available).

The significant share of Polish offshore wind projects is reflected in the projected annual demand for vessels, requiring ~20% of the global fleet (without any coordination with other developers in the area) to complete these projects.

As is the case for WTIV, also for FIV vessel demand could be reduced significantly if occupation is maximized by cooperation between projects. H-BLIX expects that, although synergies and optimizations will be found by the supply chain, the resulting vessel demand will still be towards the upper boundary, as contractors will be reluctant to fully book their vessels unless risks can be mitigated or sufficiently be covered by benefits.

Peaks in demand worldwide, in the Baltic Sea and in Poland are expected to flatten to a certain extend for reasons described in Part 4.

Figure 24 – FIV demand lower and upper boundaries - Baltic Sea and Poland



Source: H-BLIX

PART 6: Cable laying vessels

WindEurope

POLISH WIND ENERGY ASSOCIATION

H-BLIX

LITTLE GROWTH IN WORLDS CABLE LAYING VESSEL FLEET CONFIRMED, RELATED TO SHORT LEAD TIMES. REGIONAL ALLOCATION PLAYS NO ROLE IN WORLDWIDE AVAILABILITY

Worldwide vessel supply and regional allocation

The majority of cables are installed by dedicated installation vessels such as e.g Van Oord's Nexus or NKT's Victoria. A part of cable installations – be it inter array, export cable or joint – are executed by built-for-project installation assets. In this analysis only dedicated cable lay assets are taken into account. As such the list is not exhaustive but names the most important active assets.

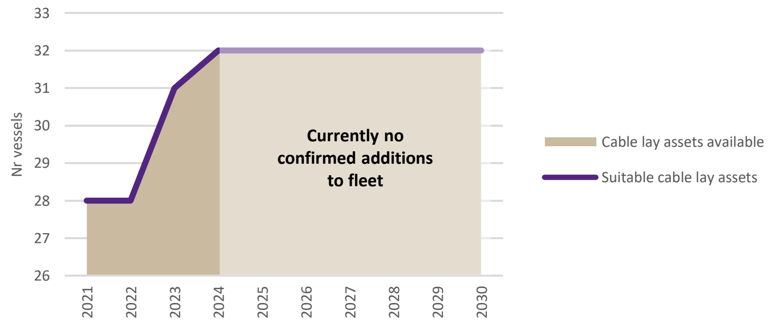
From 28 identified vessels in 2021, towards 2024 only four newbuilds are entering the market. After 2024, currently no new additions to the fleet have been identified. This is in line with a lead time of ~2-3 years for new built cable installation vessels. As a result, the figure shows a stable number of CLVs between 2024-2030, while in reality it is expected there will be an increase depending on the markets demand and investors appetite.

Cable laying assets are generally suitable to install both export, inter array and interconnector cables, some assets are also (or only) capable of joint installation. Difference in suitability for the specific tasks has not been taken into account, assuming the market will regulate itself by using a different (built-for-project) asset, without impacting the fleets average installation capacity per year.

It is expected future trends in offshore cables, such as longer/HVDC export cables or higher voltage inter array cables leading to increased size and weight of cables and joints, will not imply installation becomes impossible for certain assets (like is the case for foundation and turbine installation), only that installation becomes less optimal using certain assets. As such, cable lay assets have not been categorized, and no decline in suitability of cable installation fleet worldwide is taken into account.

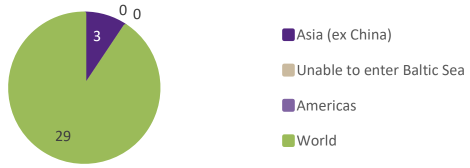
In terms of regional allocation, by 2026 four vessels are based in Asia (two in Taiwan and two in Korea). These markets however do not have as stringent regulations as e.g. the U.S.A., hence these assets may execute projects in other regions as well. As for WTIV, regional allocation is expected not to influence the worldwide market. All 32 assets can enter the Baltic Sea.

Figure 25 - Worldwide Cable Laying Vessel availability



Source: H-Blix

Figure 26 – Regional allocation of CLV by 2026



Source: H-BLIX

SIGNIFICANT INCREASE IN AVERAGE INSTALLATION CAPACITY IN GW PER CLV PER YEAR EXPECTED DUE TO LARGER PROJECTS AND TURBINES

Productivity calculation

Calculation of the required number of cable installation vessels has been performed by dividing the worlds targeted yearly capacity by an average cable installation vessel installation capacity. The average installation capacity has been calculated based on average size projects as shown in Table 21, taking into account installation of export cables, inter array cables, interconnectors and offshore joints. For each component, the average installation capacity in [GW / vessel / year] has been calculated following the same methodology as described in Part 4, and per component further detailed below. The resulting installation capacity per component has been averaged to come to an average installation capacity in [GW / vessel / year], as shown in Table 22. Pre/post lay cable burial is not taken into account, assuming in a market increasingly under pressure post lay burial will be done from a separate support vessel to maximise the cable lay capacity for cable installation.

Export and interconnector cables

Towards 2030, a large increase in installation capacity in GW/v/y is expected mainly due to increased project size, as can be seen in Table 23. The increase in project size and turbines means on average there is a larger capacity per kilometer of export cable. It is expected less projects can be executed per year due to longer installation time per project. As a result, of projects forecasted at increasing distance from shore, combined with a higher number of cables per project, CLVs will install significantly more kilometers per year while executing less projects. Also because of increased cable length, on average less time is spent on shorelanding and platform pull in. The average number of days in operation per vessel slightly increases related to increased project size. The increased project size implies an installation efficiency improvement related to relative reduction in time spent on project without productivity such as e.g. (de)mob, transit time, idle time, etc. This is reflected in the difference in both clean and real average installation length per day, between 2021 and 2030.

The time required for interconnector cable installation is calculated using the forecasted yearly installation lengths as shown in table 21, taken from TYNDP 2020 (multiplied with factor 1,5 to account for the worldwide portfolio) and the related forecasted average of 400 km length per interconnector. This installation time is divided over the number of identified CLVs and averaged over years 2021-2030. The resulting 40 days/v/y is deducted from the estimated max. number of working days / vessel / year, shown in Table 23.

Table 21 – Worldwide cable pipeline

World ex China	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Cum.
Avg. project size * [GW]	0,49	0,58	0,67	0,76	0,84	0,93	1,02	1,11	1,20	1,29	-
Avg. turbine size [GW]	9,1	10,0	10,9	11,8	12,7	13,6	14,5	15,4	16,3	17,2	-
No of projects [-]	9	18	22	28	31	26	24	34	37	40	270
Export cable length ex China [1000 km]	0,46	1,06	1,48	2,18	2,68	2,44	2,52	3,89	4,49	4,94	26,16
Interconnector cable length [1000 km]	1,08	0,23	3,62	1,05	1,39	3,37	5,73	0,75	2,82	1,31	21,35
No of array cables ex China [x1000]	0,55	1,15	1,47	2,00	2,28	1,94	1,88	2,73	2,98	3,33	20,31
No of joints ex China [-]	14	32	45	67	82	75	77	119	137	152	800

Source: H-BLIX based on 4C Offshore [D9] and WindEurope

Table 22 – Average vessel production capacity – averaged over export/interconnector, inter array and joints

Average cable installation production capacity	2021	2030
Avg. installation capacity [GW / v / y]	**1,41**	**2,48**

Source: H-Blix

Table 23 – Average vessel production capacity and its components - export and interconnector installation

Export and interconnector	2021	2030
Avg. installation capacity [GW / v / y]	**1,27**	**2,59**
Avg. number of projects per year / v / y	2,6	2,0
Avg. km export cable / v / y	129	249
Avg. no of days in operation / v / y	222	255
Clean avg. install. length - km / day (incl. loading)	2,4	2,9
Real avg. install. length - km / day (incl. loading + all other project effects)	0,6	1,0
Maximum number of working days / v / y *	260	260

Source: H-Blix

* estimated 300 reduced by 40 days for interconnector installation

THE NUMBER OF ASSETS REQUIRED PER INSTALLED GW WILL REDUCE SIGNIFICANTLY FOR INTER ARRAY INSTALLATION, FOR JOINT INSTALLATION AS WELL BUT TO A SMALLER EXTEND

Productivity calculation – continued

Inter Array

Also for inter array installation, a large increase in installation capacity [GW/v/y] is expected because of increasing turbine size and increasing number of turbines per project, resulting in same advantages as described for export and interconnector cables. Less projects are expected to be executed per year due to longer installation time per project, the average number of days in operation remains roughly the same. Inter array cable installation is not significantly affected by array cable length. Small technological advancements are taken into account with expected reduction in installation time per array. The average installation time including loading remains stable, however towards 2030, as increased turbine rotor diameter implies larger distance between turbines hence longer array cables and longer loading times.

Joints

The number of joints to be installed is determined based on the estimated yearly export cable lengths. Interconnector is left out, as this is generally done from the cable installation vessel and as such is taken into account as part of other project effects.

The number of joints is determined by estimating the max cable length based on the average carousel capacity, divided by 70t/km for DC and 120t/km for AC, factored for inefficiency due to project effects such as suboptimal usage of carousels, additional shore landing joints, etc. The average no of joints per km is calculated with a weighted average taking into account an expected 75% AC and 25% DC export cables worldwide up to 2030.

Also for joint installation an increase in installation capacity per vessel per year is expected for the same reasons as described above. Less projects but more joints will be installed per vessel per year, possible because of increased inefficiency due to increased project size. The vessels average number of days in operation remains roughly the same. Efficiency gain is due to less time lost due to increased project size.

Table 24 – Average vessel production capacity and its components – inter array and joint installation

Inter Array	2021	2030
Avg. installation capacity [GW / v / y]	**1,0**	**1,9**
Avg. number of projects per year / v / y	2,1	1,5
Avg. km or array cables respectively / v / y	121	124
Avg. no of days in operation / v / y	236	214
Avg. no. array installed / day (incl. loading)	1,6	1,6
Avg. no. array installed / day (incl. (de)mob + all other project effects)	0,5	0,6
Maximum number of working days / y *	260	260
Joint production	2021	2030
Avg. installation capacity [GW / v / y]	**1,97**	**2,95**
Avg. number of projects per year / v / y	4,0	2,3
Avg. length export cable per project [km]	49,7	125,7
Avg. no joints per project [-]	1,5	3,8
Avg. no of days in operation / v / y	255	219
Avg. install. time - days / joint (incl. loading)	7,0	7,0
Avg. install. time - days / joint (incl. (de)mob + all other project effects)	41,6	24,9
Maximum number of working days / y *	260	260

* estimated 300 reduced by 40 days for interconnector installation
Source: H-Blix

MARKET TRANSFORMS FROM OVER- TO UNDERSUPPLIED. A SIGNIFICANT DEFICIENCY IN INSTALLED CAPACITY IS EXPECTED. BALTIC SEA MAY FACE UNDERSUPPLY UP TO NON-AVAILABILITY OF ASSETS

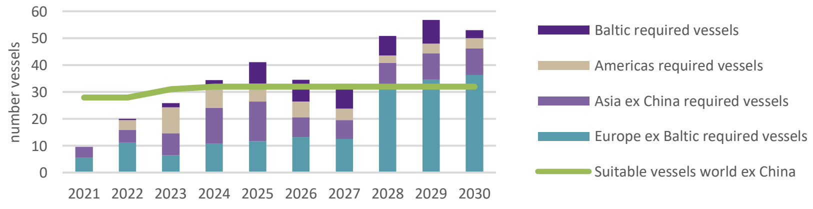
Supply vs demand – World and Baltic Sea

For analysis purposes it is assumed cables are installed in the year prior targeted yearly added capacity. The worldwide CLV demand is shown per region in line with targeted yearly added capacity as explained in Part 2 of this report. Again it is expected demand peaks will be spread out over adjacent years, be it because of unavailability of installation assets or because other stakeholders are unable to facilitate development in time.

In 2024-2025 and 2028-2030, vessel demand exceeds worldwide available and suitable installation assets (Figure 27). Without new additions to the fleet, in 2024-2025 the market would be unable to install 3,7 GW per year, due to an average gap of 5,8 CLVs. From 2028 onwards, the market could even miss installation of 16,9 GW capacity per year, due to a gap of 21,5 CLVs. As CLVs can be delivered relatively quickly, the 2024-2025 gaps could still be closed if involved stakeholders act quickly and decisively.

For developments in the Baltic Sea and Poland - as is the case for any development worldwide - the worldwide shortage is a risk to planned project execution. Market dynamics such as contractors preferences or early asset reservation elsewhere could result in Baltic Sea developments having insufficient or in some years worst case no installation asset at their disposal.

Figure 27 – CLV demand versus supply



Source: H-BLIX

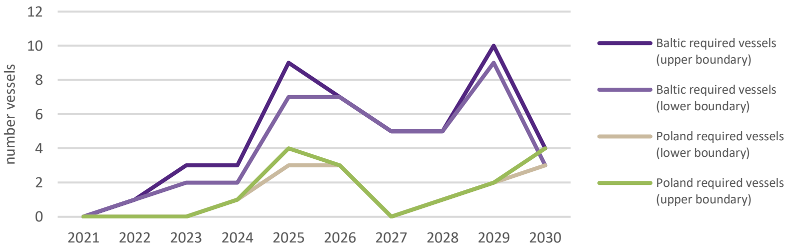
Demand - Baltic Sea and Poland

On average 6,0 (lower boundary) to 6,7 (upper boundary) CLVs are expected to be required to ensure development of targeted capacity in the Baltic Sea in the period 2025-2030, with peaks of up to 9 and 10 vessels in 2025 and 2029 respectively. Poland's significant share of to be installed offshore wind in the Baltic Sea is reflected by its requirement for on average 2,0-2,3 CLVs during the period 2025-2030, with peaks in yearly vessel demand of up to 4 in 2025 and 2030, as can be seen in Figure 28.

For the Baltic Sea as a whole, it can be seen the vessel demand could be reduced to some extent if contractors and project developers achieve to maximise vessel occupation by cooperation. For Poland, from 2026 to 2029 Figure 28 shows no optimisation in vessel usage can be made. Rescheduled projects and cooperation between developments in Poland and other countries in the Baltic could however still allow for optimisation.

H-BLIX expects that, although synergies and optimizations will be found by the supply chain, the resulting vessel demand will still be towards the upper boundary, as contractors will be reluctant to fully book their vessels unless risks can be mitigated or sufficiently be covered by benefits.

Figure 28 – Upper and lower boundary for required CLV in Baltic Sea and Poland



Source: H-BLIX

PART 7: Other vessels

OSS INSTALLATIONS ARE RELATIVELY SHORT PROJECTS PLANNED IN BETWEEN OTHER HEAVY LIFT JOBS, THEREBY IMPACTING FOUNDATION INSTALLATION VESSEL AVAILABILITY

Offshore substation installation

Offshore substation (OSS) foundation weights generally start at 1500t and heavier (excluding piles), topside weights start at 2000t and heavier.

Foundation installation entails first the installation of piles, usually installed by means of a subsea template and (vibro) hammer, followed by installation of a jacket generally done by single lift.

OSS installation is generally done by single lift, alternatively by means of float over using a submersible asset. The latter is not taken into account in this study.

The identified FIVs have been assessed on their capability to install topside and jacket, as can be seen in figure on the right. For further details reference is made to Appendix B.

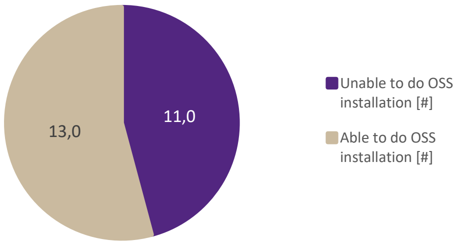
Installation of foundation and topside are relatively short operations, executed in between other offshore wind and e.g. oil and gas projects. They are often separate campaigns executed by different vessels.

OSS topside installation on is estimated to take an average of 1 week including transit and project effects such as WoW and inefficiency. The average time required for OSS foundation installation is estimated to be 1,5 weeks. OSS foundation installation is seen to be included in wind turbine foundation installation campaigns more often, which may result in a reduction of time.

The time required for the worlds OSS topside and foundation installation is calculated using numbers as shown in Table 25, by including 1,25 OSS per 1200 MW project in line with WindEurope Vision for EU Ports [D14], multiplied with worldwide number of projects and required install. time, divided by the yearly available number of FIV. The resulting 20 days/v/y is taken into account in FIV availability as explained in Part 4.

As offshore substation installation is executed by (the larger) FIVs, a shortage in FIVs will also affect availability of vessels for OSS installation.

Figure 29 – Worldwide available FIV OSS installation ability (foundation & topside)



Source: H-BLIX

Table 25 – Worldwide OSS pipeline

World ex China	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Cum.
Avg. project size * [GW]	0,58	0,67	0,76	0,84	0,93	1,02	1,11	1,20	1,29	1,38	-
No of OSS projects [-]	19	13	19	22	19	19	28	55	62	68	302
No of OSS [-]	11	15	22	27	25	26	40	46	53	61	327

Source: H-BLIX based on 4C Offshore [D9] and WindEurope

THE OSV MARKET IS AN OVERSUPPLIED MARKET WITH A CHALLENGING OUTLOOK

Offshore Support Vessels (OSV)

Besides the three types of large construction vessels, operations offshore are supported by a variety of smaller vessels. The involvement of these vessels starts already during the preparation phase of the windfarm during for example site and soil investigation campaigns. During construction OSVs support with a wide variety of tasks, such as deployment of bubble curtain systems; post lay burial; anchor handling; towing and manoeuvring during feeder and supply operations; guard and monitoring; grouting operations; diving and subsea support; crew transfer; etc.

Considering the major OSVs, their ability to perform their designated task is often realized by the mobilization of a project specific deck-spread. As such vessel characteristics are similar for most scopes. For the majority of work, a large deck, DP capabilities, a walk-to-work system and accommodation possibilities are crucial.

The vast majority of these OSVs have not been purposely build for offshore wind. OSVs have been, and still are, crucial for offshore operations in the oil & gas sector. The OSV sector has been very challenging for almost a decade, starting with the oil crisis, vessel oversupply from Asia, long-term low oil prices, increase of shale-oil production and covid. Although the market is recovering, still one-third of the global market (over a thousand vessels) of OSVs is idle, being laid-up or nominated for scrapping. With new projects in oil & gas and the described increase in offshore wind a portion of these vessels will become active again as-is or converted to today standards.

Despite the market being oversupplied in terms of quantities, the number of OSVs suitable for supporting offshore wind projects is limited. Many laid-up OSVs are outdated to today standards. Due to the nature of repetitive offshore operations, besides the main installation vessel, all in field assets should be optimal fit for the job. Developers and contractors tend to contract vessels with the right specifications, such as DP, high workability, sufficient deck space, low emissions and modern facilities on board. Based on interviews with owners and brokers it is recognized that the current oversupplied market will be more challenging for the second half of this decade.

To ensure availability of supporting assets, developers and contractors tend to secure OSVs well upfront. Parties with multi-project portfolio, able to sign long term charter contracts for OSVs, are expected to have first choice, affecting availability of suitable vessels for others not able to sign long term charters.

The demand for suitable vessels poses an opportunity for smaller sized shipyards worldwide, for the conversion and upgrade of existing OSVs or for the new build of assets. These works can be performed by many shipyards in the region, not requiring large dry-docks compared to installation vessels.

Designs of new build OSVs are largely of the shelf and some suppliers have empty casco's ready for final fitting. With construction lead times for these vessel being less than 3 years, the market is expected to be able to react to the upcoming demand. Investments in conversion or newbuild by owners do however require a stable outlook, something that has been lacking over the past decade. Although the Baltic Sea has the advantage of benign weather conditions, thus reducing the specifications to achieve desired workability, it is still expected that all OSVs will be built on spec for North-Sea / global operations, as suitability for the Baltic Sea only could prove a risky investment.

OPPORTUNITIES FOR VESSEL OWNERS DURING THE OPERATION PHASE OF WIND FARMS

Service & Operation Vessels (SOV) / Crew Transfer Vessels (CTV)

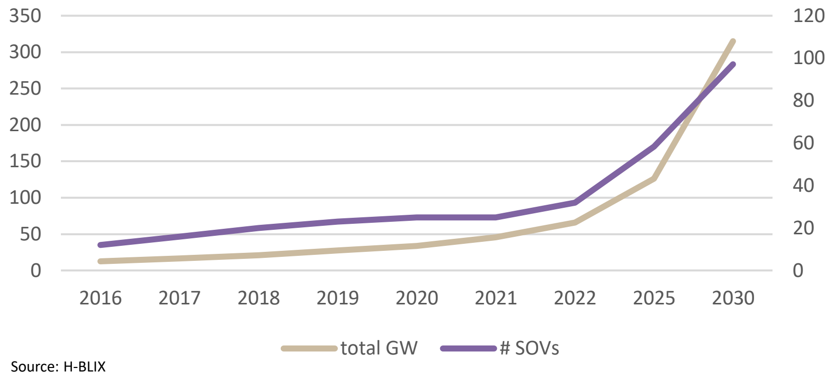
Daily windfarm maintenance is performed by Service & Operation Vessels (SOV) and Crew Transfer Vessels (CTV). SOVs are “Swiss pocketknife” assets that stay in the windfarm for two weeks and only come to port for supplies and crew change. For the vast majority of tasks, they are self-supporting. Supported by a walk-to-work system and often a daughter craft they transfer technicians to the turbines. Currently 32 SOVs are in operation on offshore wind farms worldwide [S7]. CTVs commute every day from port to the windfarm. With speeds reaching up to 40 knots, transit takes up to 2 hours, for windfarms far offshore.

The type of vessels used for daily windfarm maintenance is very much depending on the O&M strategy of the windfarm owner. The optimal strategy depends on various parameters: the number of WTGs, the distance to port, the metocean conditions, the maintenance strategy, contracting strategy and of course the business case. In general, the bigger the windfarm and the greater the distance to port, the more likely the O&M strategy will be based on an SOV. When using CTVs for larger wind farms, a significant part of the technician's shift will be spent on transit. When using CTV, the actual working time on a turbine during a 12 hours shift is just 7 hours, compared to 10 hours when using SOV [D17]. In addition: an SOV also allows for a shared asset between nearby windfarms of the same owner.

SOVs and CTVs are mostly procured on the project. Leadtime for these on-spec build SOVs ranges between 2 and 3 years, whereas CTVs are often less custom-spec with a shorter lead time.

The average distance from wind farm to shore has been increasing and will further increase towards 2030. It is expected that the majority of new projects further offshore will use a SOV for O&M. Analysis show that up to a 100 SOVs could be active on offshore wind farms in 2030. All offshore wind farms in the Baltic Sea currently use CTVs, but all are within acceptable range of O&M ports. For the future offshore wind farms, the average distance to port is on average 60 kilometres, making it most likely that SOV will be used, despite the calmer Baltic Sea conditions.

Figure 30 – Number of SOVs worldwide [S7], including extrapolated forecast 2025/2030



Source: H-BLIX

Comparing workability between CTVs and SOVs it can be seen that the year-round workability of a CTV based O&M strategy is around 60%, limited by 1.5 m wave height. Whereas SOVs can transfer personnel up to Hs 2.5m, resulting in a workability around 80% [D17/D18]. When combining workability with actual working hours on a turbine, SOV based operations allow an owner to perform almost double the amount of work as with CTV based maintenance. With the increase of distance to port and the size of future wind farms, the share of operation by SOV is expected to increase.

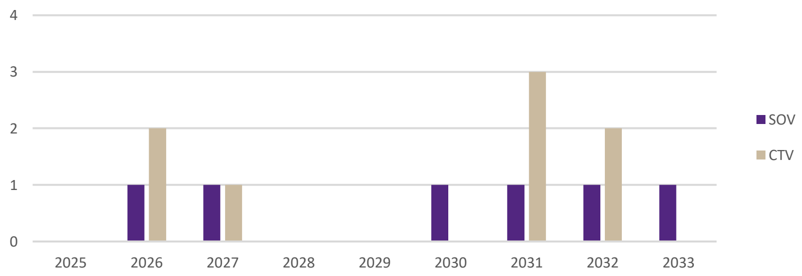
Service & Operation Vessels (SOV) / Crew Transfer Vessels (CTV)

Taking into account developments till 2030 in the Polish offshore wind market, an analysis is made on the required SOVs and CTVs. All projects have been analysed on distance to port and number of turbines. Synergies between windfarms of the same owner have been considered. Based on developments in the Baltic and North Sea it is assumed that smaller projects (<50 WTG) closer to shore (<50km) will most likely being serviced by CTVs, whereas bigger projects or projects further offshore will make use of SOVs. This assumption is in line with commissioned offshore wind projects worldwide that use a SOV [D18].

It is assumed that a SOV or CTVs will be required from the year of COD onwards. The results are shown in figure 31, this graph includes expected synergies between projects. CTV based projects will require multiple CTVs (on average: CTV/20*WTG) being present permanent on the project. During bigger maintenance campaigns the fleet of CTVs will be enlarged temporarily.

This results in an expected outlook of 6 SOVs and 16 to 21 CTVs to be required up to 2033 for the Polish offshore wind market. SOVs could also play a vital role during commissioning (CSOV), this would shift the need for these vessels to 1-2 years earlier.

Figure 31 – Number of CTV or SOV required for Polish offshore wind farms, based on COD date



The Baltic metocean climate poses a unique opportunity for the SOV market. SOVs and regular OSVs have many similarities, allowing for conversion of OSVs into SOVs. This conversion also comes with several challenges, like the need for sufficient and modern accommodation facilities. For SOVs station keeping on DP with minimal vessel motions is of highest importance. This reflected in the hull and vessel design and results in a high workability.

Many OSVs have not been designed with that qualification as highest priority, more focussing on efficient transit. This could result in more residual motion and thus lower workability during walk-to-work operations. Nevertheless, several successful conversions have been done in the past, like Wagenborg's Kasteelborg, based on an Ulstein design and more recently the Norwind Breeze by VARD. With wave conditions in the Baltic Sea being more benign compared to the North Sea [S8], the conversion of existing OSVs should be considered as a very feasible option for the Polish market instead of new build.

PART 8: Conclusions and recommendations

Wind EUROPE

POLISH WIND ENERGY ASSOCIATION

H-BLIX

1. **Accelerated growth in offshore wind capacity installation towards 2030, both worldwide as well as in the Baltic Sea and Poland**
   - As indicated by all recent forecasts, including that prepared specifically for this report, the current, already high growth in offshore wind installation capacity will experience significant acceleration, especially towards the end of the decade. In 2030, 52 GW new offshore wind is forecasted to be installed worldwide, almost as much as the 57 GW online worldwide in 2021. The Baltic Sea and Poland will also see accelerated growth, with a number of projects being developed for commissioning from 2026 onwards.
   - The 316 GW worldwide, forecasted based on -amongst others- current offshore wind project advancement and recently announced government targets (including Esbjerg Declaration), will materialize only in favorable regulatory environment with fully capable supply chain of adequate capacity, to mention only two of many key enablers.
2. **First shortage of installation vessels for foundations and turbines in 2024 and 2025 respectively, followed by a drop in demand in the next two years**
   - Despite the influx of new foundation installation vessels (FIV) and wind turbine installation vessels (WTIV) towards 2026, the study predicts a shortage of these asset types in the near future: for FIV starting in 2024, for WTIV starting in 2025.
   - Due to a worldwide shortage of 2,3 and 3,8 FIV in 2024 and 2025 respectively, installation of 2,0 and 3,8 GW may need to be rescheduled. Despite a drop in required FIV in 2026-2027, postponing projects from 2024-2025 does not solve the undersupply. Averaged over years 2024-2027, a shortage of 0,5 FIV remains. These estimates do not include potential work in the oil and gas industry, which may worsen the situation.
   - Without new additions to the global fleet, over 2025-2026 the market would be unable to install 6,4 GW, due to an average gap of 3,7 WTIVs. Despite the drop in required WTIV in 2027-2028, the market will still experience an undersupply of vessels.
   - Due to design and production lead time of 3-4 years, for both FIV and WTIV the identified supply vs demand gap may be very difficult to bridge within the available timeframe. As a result, projects may need to be rescheduled.
3. **Very significant shortage of FIV and WTIV in the period 2028 – 2030, which can be bridged on time by new vessels**
   - Towards 2030, some vessels will become unable to install increasing turbine/foundation sizes due to insufficient crane capacity, reducing the no. of suitable installation vessels.
   - In case no new vessels are commissioned after 2026, one may expect a very significant supply vs demand gap for FIV and WTIV between 2028 and 2030.
   - For FIV the gap starts in 2028 and, if not bridged, would result in the need to re-schedule installation of ca. 12 GW per year (36,7 GW in total), due to an average shortage of 8,8 FIVs from 2028 to 2030.
   - For WTIV the gap starts in 2029 and, if not bridged, would result in the need to re-schedule installation of ca. 14,9 GW per year (29,9 GW in total), due to an average gap of 12,2 WTIVs over 2029 – 2030 period.
   - Floating wind is expected to slightly reduce the FIV demand peaks in 2028 – 2030.
   - For this period, there is still sufficient time to build the required number of new vessels. As a result, one may expect that new assets will be added to the fleet, with operators taking investment decisions at a later stage when more information will be known about foundation and turbine parameters to be handled by these vessels.
4. **Similar shortage pattern for CLV (2024 – 2025 and 2028 – 2030) with even greater gap to be bridged**
   - A similar situation is expected with cable-laying vessels (CLV), were in 2024-2025 and 2028-2030, vessel demand exceeds supply. Without new additions to the fleet, in 2024-2025 the market would be unable to install 3,7 GW per year (7,4 GW in total) due to an average gap of 5,8 CLVs (for comparison in 2025 Poland will need 3-4 CLVs and the entire Baltic Sea 7 to 9 CLVs).
   - Between 2028-2030, the world market could miss installation of on average 16,9 GW capacity per year (50,7 GW in total), due to an average gap of 21,5 CLVs.
   - As CLVs can be delivered relatively quickly (~2-3 years lead time), the 2024-2025 gaps could still be closed if involved stakeholders act quickly and decisively.

5. **Worldwide shortage of FIVs, WTIVs and CLVs poses risk for project execution worldwide as well as in the Baltic Sea and Poland**
   - For offshore wind farm projects in the Baltic Sea and Poland, the worldwide shortage poses a risk to planned project execution. Depending on the actual worldwide market development and the actual supply vs demand gap, especially in the period 2024 – 2026, Baltic Sea projects, including Polish ones, may have insufficient or worst case no installation assets at their disposal during currently planned offshore construction period.
   - For the Baltic Sea and Poland, upper and lower boundaries in vessel demand have been determined, whereby the number of vessels required depends on the level of cooperation between developers and contractors.
   - During the peaks of 2025 – 2026, within the Baltic Sea 5-9 turbine installation vessels, 5-10 foundation installation vessels and 7-9 cable lay vessels are estimated to be required. For Poland alone, 2-5 FIVs, 2-3 WTIVs and 3-4 CLV will be needed in 2025 and 2026.
   - As such, in 2025-2026 the Baltic Sea requires a significant share of the worldwide vessels suitable to install foundations, cables and turbines. The required share of the fleet (22-43% of the worlds FIV, 20-36% the worlds WTIV and 22-28% of the worlds CLVs) is disproportional to the Baltic Sea's share of the worldwide added offshore wind capacity in GW per year (19% share of capacity to be installed worldwide).
   - In 2029 - 2030, the required share of the fleet increases even further
   - The real number of vessels is expected to tend towards the upper boundary, as developers tend to focus on delivering their own project in a very competitive market.
6. **Considering the potential shortage, it is vital for the Baltic Sea and Polish Wave I projects to secure the availability of installation vessels as soon as practically feasible**
7. **Forecasted shortages in supply versus demand may be bigger than presented due to large unforeseen events not taken into account in the analysis**
   - Project execution will rarely be entirely according plan. In some occasions large unforeseen events -be it in supply chain, installation execution or somewhere else- will have a significant impact on project execution.
   - Where the market tightens and occupation of installation vessels is maximised, the chance of knock-on effects to other projects increases.
   - This effect has not been taken into account in this analysis, but it does imply that in a tight market the vessel demand will increase further.
8. **The shortage of vessels appears to be due to difficult business case for new builds and a number of risks which need to be addressed by the governments and the industry**
   - In general, the ability to install worldwide targeted capacity depends amongst others on governments to actively facilitate offshore wind development by creating the right conditions in terms of legislation, funding, supply chain and infrastructure as well as on (local) availability and suitability of critical installation infrastructure such as ports and the supply chain of components.
   - For installation vessel availability and new additions to the fleet, several key challenges and risks have been identified, related to the difficult business case for newbuilds: next to uncertainty regarding governmental progress in permitting and establishment of required infrastructure, vessel specific realization of estimated annual work volume, the unclarity related to future turbine and foundation sizes poses a risk of a newly acquired installation vessel being either too small (reducing the time it can operate in the field) or too big (making it too expensive).

- To increase the willingness to invest, governments and developers could provide a pro-investment environment by:
  - Avoiding negative bids for new leases, as it will lead to less investments in the wind supply chain, which is already struggling to be a healthy industry to invest in;
  - Streamlining governmental permitting process, as presented by WindEurope [D16];
  - Enforcing clear outlooks through tendering specifications, e.g. by increasing tendering scopes and spreading them over multiple years to provide utilization security for investors and/or steering implementation of developments through imposed regulation in installed turbine size;
  - Facilitating the entire supply chain for building new vessels, including the supply chain for all equipment on board (e.g. heavy lift cranes, grippers, DP systems, cable lay equipment). This relates to materials, fabrication infrastructure as well as people to do the work.
- Limit restriction of markets through local content requirements such as e.g. the Jones act, implying high vessel building costs making the investment for a new vessel more difficult and increasing local offshore wind development costs.

9. Providing the aforementioned gaps are bridged, by 2030 35 WTIV, 32 FIV and 57 CLV will be in operation, capable of installing ca. 47 GW of new offshore wind capacity annually on worldwide basis

- With global goals beyond 2030, increasing until 2050, there is stable demand for services for new installation vessels.

10. Availability of SOV should not pose a problem for O&M activities, but do require significant investments in newbuild or conversions

- In general Service Operation Vessels (SOV) availability should not pose a problem during wind farm O&M activities, as SOVs can either be newbuild or adapted from vessels used previously for other purposes. Availability of required number of SOVs will demand a significant investment, which in general may benefit local shipyards.
- For Poland 2 SOV by 2027 and up to 6 by 2033 are required.

11. Considering Baltic Sea and Polish offshore wind potential, Poland may use the currently developing opportunity to create an offshore wind industry to serve local and international markets

- Considering forecasted offshore wind capacity to be installed for Wave 1 and Wave 2 Polish projects (5,9 GW and 11,3 GW respectively) as well as further potential capacity of the Polish EEZ, which is currently being analyzed, Poland has a unique opportunity to become an offshore wind hub, firstly for its own projects, with potential expansion across the Baltic Sea.
- Despite a drop in demand during the period 2026 – 2027, in general from 2024 onwards there will be a need for new installation vessels to be added to the fleet. Poland may use this opportunity to enter vessel design and construction market, bearing in mind risk and limitations for investment presented above.
- Poland may also be in a good position to deliver service operation vessels (SOV) and crew transfer vessels (CTVs), which will be required in greater numbers and for much longer periods, post COD.

12. To become a significant player in the offshore wind industry Poland may need to address a number of challenges, especially related to regulatory framework and installation port(s).

- Timely availability of installation ports in sufficient numbers, especially for foundation installation, which for Wave I projects is to start in 2024. In the future the ports may need to be geographically dispersed to serve different parts of the Baltic Sea
- Stability of legislative framework with lower number of various permits, certificate and expert opinions required to file for the construction permit, which has not yet been issued for any wind farm in Poland.
- Shortage of personnel for maritime coordination and implementation of EIA decisions regarding e.g. installation window, simultaneous pilings, etc.

PART 9: Appendices

MAIN OFFSHORE WIND VESSEL OPERATORS

The following table presents main offshore wind vessel operators.

Table 26 – List of main offshore wind vessel operators.

No.	Operator	About	Contact details
1	Asso divers	Asso Group has been actively involved in offshore and nearshore activities since its establishment in 1976. During its operation, Asso.subsea has maintained a cutting edge technology driven profile acting either as a turnkey solution provider or as a subcontractor to major cable installation companies and marine contractors. Since 1985, Asso.subsea has been the leading contractor for all Greek related cable projects for both land and sea works. Specializing in submarine cable installation, protection, repair and support operations, Asso.subsea has established a constantly updated long track record of participations, not only in domestic, but also in worldwide projects.	69 Okeanidon & 38 Charilaou Trikoupi Str. Elefsina, 192 00, Greece, central@assogroup.com (+30) 211 8885100 https://www.assogroup.com/
2	Boskalis	We offer the widest range of expert dredging, offshore transport and installation solutions, as well as maritime services, including towage and salvage, in our industry. As a result we can provide innovative, one-stop solutions to meet every challenge.	Rosmolenweg 20, 3356 LK Papendrecht The Netherlands, +31 78 6969 000 royal@boskalis.com, https://boskalis.com/
3	Cadeler	Cadeler operates two highly efficient Windfarm Installation Vessels (WIVs), Wind Orca and Wind Osprey. In addition to offshore wind farm installation, these vessels are very well suited for a wide range of maintenance, construction and decommissioning tasks.	Fairway House, Arne Jacobsens Allé 7 DK-2300 Copenhagen S, +45 3246 3100 enquiry.DNK@cadeler.com, https://www.cadeler.com/en/about/cadeler/
4	CDWE	CSBC-DEME Wind Engineering Co. Ltd. (CDWE), a joint venture between CSBC Corporation, Taiwan and DEME Offshore from Belgium. Combining the knowledge and experience of the Shareholders, we offer global solutions related to the construction of offshore wind farms in Taiwan, from transport and installation activities to full Balance of Plant projects.	6F, No.20, Sec 3, Bade Rd., Songshan District., Taipei City 105, Taiwan +886 2 2577 0612, info@cdwe.com.tw, https://www.cdwe.com.tw/en/
5	DeepOcean	DeepOcean is a technology-driven, independent solution provider in the ocean space. We offer companies within oil and gas, offshore renewables, deep sea minerals, and other non-energy niches a full range of services – from surveys, engineering, project management, and installation to maintenance and recycling.	Henrik Ibsensgate 4 0255 Oslo Norway (+47) 22 76 06 00 post@deepoceangroup.com, https://www.deepoceangroup.com/vessels/deep-vision
6	DEME	DEME is a world leader in the highly specialised fields of dredging and land reclamation, solutions for the offshore energy market, environmental and infra marine works. While our roots are in Belgium, DEME has built a strong presence across the globe. We have a versatile and modern fleet of more than 100 vessels, supported by a broad range of auxiliary equipment	Haven 1025, Scheldedijk 30, 2070 Zwijndrecht, Belgium, +32 3 250 52 11 info@deme-group.com, https://www.deme-group.com/
7	Dominion resources	More than 7 million customers in 16 states energize their homes and businesses with electricity or natural gas from Dominion Energy (NYSE: D), headquartered in Richmond, Va. The company is committed to sustainable, reliable, affordable and safe energy and to achieving net zero carbon dioxide and methane emissions from its power generation and gas infrastructure operations by 2050.	DominionEnergy.com
8	Dong Fang Offshore	DFO (Dong Fang Offshore) was established in 2019 as a subsidiary of HHC (Hung Hua Construction Group), the leading Taiwanese maritime EPC contractor. DFO actively promotes the development of offshore wind power and collaborates closely with major developers, international EPC contractors and turbine OEMs in the consenting, construction and O&M phases of offshore renewable energy projects in Asia Pacific.	11F., No.257, Xueshi Rd.,North Dist., Taichung City 404, Taiwan (R.O.C.), +886-4-22060667, admin@dfo.com.tw, https://www.dfo.com.tw/
9	Dutch offshore	Dutch Offshore owns a compete portfolio of equipment, and charters this to the maritime and offshore industry with a 24/7 service package. Dutch Offshore offers: lattice and telescopic crawler cranes for multiple offshore and marine applications, a fleet of Dynamic positioning (DP2) vessels, multipurpose and modular (crane)barges, special offshore equipment - grabs, winches, etc., a strategic yard location in the main port of Amsterdam.	PO Box 37854, 1030 AN Amsterdam, The Netherlands +31 20 74 00 527 info@dutchoffshore.com https://dutchoffshore.com
10	Eneti Inc	Eneti's strategy is to deliver sustainable long-term value to our stakeholders by building a meaningful and sustainable business in marine-based renewable energy, including investing in the next generation of wind turbine installation vessels.	PRINCIPAL EXECUTIVE OFFICE Le Millenium 9, Boulevard Charles III MC 98000 Monaco +377 9798 5715, https://www.eneti-inc.com/
11	Fred. Olsen Windcarrier	Fred. Olsen Windcarrier provides efficient and cost-effective transport, installation and service solutions to support you across every stage of the wind farm lifecycle. We are committed to the future of offshore wind energy, supplying industry-leading expertise, solutions and hardware to help you establish tomorrow's offshore wind gigaparks.	Fred. Olsens gate 2, 0152 Oslo, Norway +47 22 34 10 00 info@windcarrier.com, https://windcarrier.com/
12	Global Marine	Global Marine is a leading provider of subsea engineering, responding to the subsea fibre-optic cable installation, maintenance, repairs and burial requirements of our customers globally. Global Marine is part of the Global Marine Group. The company has a legacy of over 160 years in both deep and shallow water operations and operates worldwide with head offices located in Chelmsford, UK and Singapore.	Global Marine, Ocean House, 1 Winsford Way, Chelmsford, Essex CM2 5PD, United Kingdom +44 (0)1245 702000, info@globalmarine.group, https://globalmarine.co.uk/
13	Hafvram	Havfram is a subsea and offshore wind contractor with a global footprint headquartered in Stavanger, Norway	Stavanger, Norway, Kanalsletta 8, Forus P.O. Box 8070, N-4068 Stavanger +47 51 95 70 00 post@havfram.com, https://havfram.com/
14	Heerema	The Heerema companies deliver solutions and create sustainable value(s) on projects within the offshore energy industries. Company delivers innovative and sustainable solutions for the transportation, installation, and removal of offshore infrastructure	https://www.heerema.com/our-locations
15	High Tien	High Tien Offshore Co., Ltd. was established in 2021. Its main business is submarine cables laying and repairs. The company will have the first large Taiwanese Cable Laying Vessel, which will Connect Local Vessels and Create Local Value in order to ensure the independence of Taiwan's energy and communications security.	32nd Floor, No. 99, Section 2, Dunhua South Road, Da'an District, Taipei City, +886 2 2700 8588, contact@ht-offshore.com,
16	Jan de Nul	Jan De Nul is a tier one marine contractor with expertise in EPCI offshore services, capable of a full balance of plant delivery as well as T&I contracting. Our extensive fleet and integrated approach enable us to perform all activities throughout the entire life cycle of offshore structures. From the very first design to the execution and even the decommissioning we meet the client's needs with overall solutions.	Jan De Nul nv, Tragel 60 9308 Hofstade-Aalst, Belgium +32 53 73 15 11, info@jandenul.com https://www.jandenul.com/

Source: H-BLIX based on operator websites.

MAIN OFFSHORE WIND VESSEL OPERATORS

The following table presents main offshore wind vessel operators.

Table 27 – List of main offshore wind vessel operators.

No.	Operator	About	Contact details
17	LS Cable&System	LS Cable & System, established in 1962, has been contributing to building power grids and communication networks first in Korea and then in countries all over the world by developing, producing and providing cables and related solutions used in daily life and throughout many industries. Furthermore, the company set the stage for industrial and economic development by capitalizing on our innovative technology to supply various special industrial cables and industrial materials.	12nd-16th Fl. LS Tower, 127 LS-ro, Dongan-gu, Anyang-si, Gyeonggi-do 14119 Korea + 82-2-2189-9114, http://www.lscns.com/en/main.asp
18	Maersk Supply Service	Maersk Supply Service is a leading provider of global offshore marine services and integrated solutions for the energy sector worldwide. We serve the energy sector with a fleet of 41 vessels manned by more than 1,100 crew members and supported by around 250 onshore staff worldwide. Maersk Supply Service brings more than 50 year's hands-on marine experience in performing complex operations at sea.	Esplanaden 50, DK-1098 Copenhagen K, Denmark +45 7373 7000, https://www.maersksupplyservice.com/
19	Nexans	Nexans is developing a fleet of the world's most advanced cable-laying vessels. They can perform complex cable installation operations in all water depths, from shallow to deep, to connect offshore wind farms as well as interconnecting islands, countries, and continents.	https://www.nexans.com/en/
20	NKT	Ranging from complex submarine interconnectors to inland lakes, we operate and provide solutions whatever the requirements. With all the right equipment for reliable and cost-efficient solutions, supported by unrivalled expertise in high voltage AC and DC cable installations. We have the in-house expertise and experience of both cable and installation to be able to ensure our customers a cable project delivery on-time and on-budget.	Vibeholms Allé 20, 2605 Brøndby +45 43 48 20 00, info@nkt.com, https://www.nkt.com/
21	NPCC	NPCC was established in 1973, and is a World Class Engineering, Procurement and Construction Company, that provides Total EPC Solutions to both Offshore and Onshore Oil and Gas Sector. It provides Engineering, Procurement, Project Management, Fabrication Installation and Commissioning Services to project owners and operators.	P.O. Box 2058, Mussafah, Abud Dhabi, U.A.E +971 2 554 9000, marketing@npcc.ae, https://www.npcc.ae
22	Obayashi	We promote renewable energy, PPP and agriculture businesses. In the renewable energy business, we will implement initiatives in wind power and biomass, as well as solar power generation, with a view to entering businesses on the periphery of power generation.	https://www.obayashi.co.jp/en/
23	OIM Wind	OIM Wind are focusing on the Global Offshore wind market, and has developed Wind Installation Units with capacities to handle Wind Turbines including foundations, beyond "Next Generation" Wind Turbines" which are entering the market from 2023	Fridtjof Nansens plass 4 0160 Oslo, Norway, (+47) 996 41 320, mail@oim.no https://www.oim.no/
24	OOS	We are proud of our unique fleet which provides accommodation, heavy lift installation and decommissioning solutions with the highest safety and technological standards. From our head office in Villa Welgelegen in Serooskerke, The Netherlands, we manage our overseas operations. We have a strong local presence internationally, with offices in various countries which serve as the focal point for optimal reach and business facilities in the offshore market.	Oostkapelseweg 4, 4353 EH Serooskerke The Netherlands, +31 118 726 200, info@oosinternational.com https://oosinternational.com
25	P&O maritime logistics	Headquartered in Dubai, United Arab Emirates, P&O Maritime Logistics is a leading provider of marine solutions with a focus on offshore energy, port services and cargo transport. Operating worldwide, we own and operate approximately 400 vessels and provide a wide portfolio of value-added marine services, with the ability to integrate these offerings with our customers' operations.	6th Floor, JAFZA 17, Office Nos. 603 Jebel Ali Free Zone, PO Box 17000, Dubai, UAE +971 4 4478300 manager.corporate@pomaritime.com https://pomaritime.com/
26	Penta-Ocean	Our initial business in marine civil engineering works has significantly expanded to land civil engineering and building construction works.	https://www.penta-ocean.co.jp/english/index.html
27	Prysmian	From shallow water to deep water, from soft soils to hard soils, from single cable to bundled cables, we have the experience and assets to provide complete solutions across all manner of cable installations.	Via Chiese 6, 20126 - Milan, Italy +39 02 6449.1 https://www.prysmiangroup.com/en
28	Saipem	Working side by side with our clients we are an essential partner in every stage of development of their projects: from process and structural engineering to logistics planning, from procurement to plant construction, from maintenance, modification and operation activities (better known as MMO) to decommissioning.	Via Martiri di Cefalonia, 67 20097 San Donato Milanese (MI), +39 0244231, https://www.saipem.com/en
29	Sapura Energy Berhad	Sapura Energy Berhad is a global integrated energy services and solutions provider operating across the entire upstream value chain, including renewables. The Group's spectrum of capabilities covers exploration, development, production, rejuvenation, decommissioning, and abandonment.With a highly skilled and technically capable workforce, versatile strategic assets, and strong project management capabilities, the Group today delivers its integrated solutions and expertise in over 20 countries.	No. 7, Jalan Tasik, Mines Resort City, 43300 Seri Kembangan, Selangor, Malaysia (6)03-8659 8800, https://sapuraenergy.com/
30	Scaldis	SCALDIS is a highly experienced offshore heavy lift contractor and provides services for the oil & gas, renewables, decommissioning, civil and salvage markets. Scaldis specializes in the transportation and installation of offshore structures and the decommissioning of offshore facilities. We have earned a reputation as a solid and reliable partner, providing turnkey and cost-effective solutions in close cooperation with our clients for marine projects. Scaldis' expertise covers all the phases of installation and decommissioning projects.	North Trade Building, Noorderlaan 133 - Box 31 2030 Antwerp, Belgium +32 3 541 69 55, mail@scaldis-smc.com https://www.scaldis-smc.com/en
31	Seajacks	Seajacks operate self-propelled jack-up vessels which provide safe and efficient offshore solutions all over the world. We operate in both the Renewable and Hydrocarbon industries. With a track record of over 500 wind turbine installations, Seajacks' vessels have proven that they provide an effective solution to the installation and maintenance of offshore wind turbines and foundations. Likewise, in the offshore oil & gas sector, the vessels have brought a new dimension to maintenance; modification; construction and decommissioning of wells and platforms in the North Sea.	South Denes Business Park, South Beach Parade Great Yarmouth, Norfolk, UK, NR30 3QR +44 (0) 1493 841 400 https://www.seajacks.com/
32	Seaway 7	We support developers to bring sustainable, renewable energy to the world through the construction of fixed offshore wind farms. As a global leader in the delivery of bottom-fixed offshore wind farm solutions, Seaway 7 offers specialist foundation, offshore substation, submarine cable and wind turbine installation services and heavy transportation for the renewables sector.	Haakon VIIs gate 1, 11th floor, 0161 Oslo, Norway +47 21 01 34 50 client.enquiry@seaway7.com, https://www.seaway7.com/

Source: H-BLIX based on operator websites.

MAIN OFFSHORE WIND VESSEL OPERATORS

The following table presents main offshore wind vessel operators.

Table 28 – List of main offshore wind vessel operators.

No.	Operator	About	Contact details
33	Shimizu	Shimizu is one of the largest general contractors in Japan and has been involved in the first offshore wind pilot projects in the country. The company is currently building a jack-up with a 2500t crane for offshore wind construction. The vessel is expected to be delivered in late 2022. Shimizu has a partnership with Heerema.	2-16-1 Kyobashi, Chuo-ku, Tokyo 104-8370, Japan +81-3-3561-1111 https://www.shimz.co.jp/en
34	Subsea 7	Subsea 7 is a global leader in the delivery of offshore projects and services for the evolving energy industry. We create sustainable value by being the industry's partner and employer of choice in delivering the efficient offshore solutions the world needs.	412F, Route d'Esch, L-1471 Luxembourg communications@subsea7.com https://www.subsea7.com/en/
35	Van Oord	Van Oord provides all-round solutions taking full responsibility for entire projects for our clients. Often delivering turnkey projects, including engineering, procurement and construction, we continue to successfully execute and complete projects. We focus on Balance of Plant contracts (BoP, all supporting components and auxiliary systems other than the wind turbines) and on Transport and Installation (T&I) projects. We also provide construction services such as scour protection and inter array cable installation.	Schaardijk 211, 3063 NH Rotterdam, The Netherlands +31 88 8260000, info@vanoord.com https://www.vanoord.com/

Source: H-BLIX based on operator websites.

FIV & WTIV

The following table presents foundation installation vessels (FIV) and wind turbine installation vessels (WTIV) in operation and ordered.

Table 29 – List of FIVs and WTIVs in operation and ordered.

No.	Name	Operator	Delivery	Market	Able to enter Baltic Sea	Lift [t]	Category FIV	Hook height [m]	Category WTIV
1	Bokalift 2	Boskalis	2022	EU	Yes	4000	3	125	0
2	Bokalift 1	Boskalis	In operation	EU	Yes	2300	2	113	0
3	Asian Hercules III	Boskalis	In operation	EU	Yes	1600	1	61	0
4	Taklift 4	Boskalis	In operation	EU	Yes	1400	0	80	0
5	Fclass	Cadeler	2026	EU	Yes	3000	3	192	3
6	NG-20000X-G1	Cadeler	2024	EU	Yes	2600	2	192	3
7	NG-20000X-G2	Cadeler	2025	EU	Yes	2600	2	192	3
8	Upgraded Wind Orca	Cadeler	2024	EU	Yes	1600	1	180	3
9	Upgraded Wind Osprey	Cadeler	2025	EU	Yes	1600	1	180	3
10	Wind Orca	Cadeler	In operation	EU	Yes	1200	0	117	1
11	Wind Osprey	Cadeler	In operation	EU	Yes	1150	0	152	2
12	Green Jade	CDWE	2022	ASIA	Yes	4000	3	125	0
13	Orion	DEME Offshore	2022	EU	Yes	5000	3	135	0
14	INNOVATION	DEME Offshore	In operation	EU	Yes	1500	1	141	1
15	SEA Installer	DEME Offshore	In operation	EU	Yes	632	1	121	0
16	Upgraded Sea Challenger	DEME Offshore	2025	ASIA	Yes	1600	1	180	3
17	Upgraded SEA Installer	DEME Offshore	2023	EU	Yes	1600	1	180	3
18	Apollo	DEME Offshore	In operation	EU	Yes	800	0	158	2
19	SEA Challenger	DEME Offshore	In operation	EU	Yes	632	0	140	1
20	Charybdis	Dominion resources	2024	US	Yes	2200	2	174	3
21	conquest MB1	dutch offshore	In operation	EU	Yes	1400	0	75	0
22	Eneti WTIV	Eneti Inc	2026	EU	Yes	2600	3	190	3
23	Eneti WTIV	Eneti Inc	2024	US	Yes	2600	3	190	3
24	Upgraded Bold Tern	Fred. Olsen	2022	EU	Yes	1600	1	174	3
25	Blue Tern (6)	Fred. Olsen	In operation	EU	Yes	800	0	125	0
26	Brave Tern (6)	Fred. Olsen	In operation	EU	Yes	640	0	138	1
27	tbd	Hafvram	2026	EU	Yes	-	3	-	3
28	tbd	Hafvram	2024	EU	Yes	-	3	-	3
29	Aegir	Heerema	In operation	EU	Yes	5000	3	125	0
30	Balder	Heerema	In operation	EU	No	2720	3	-	0
31	Sleipnir	Heerema	In operation	EU	No	20000	3	185	0
32	Thialf	Heerema	In operation	EU	Yes	14200	3	144	1
33	Les Alizes	Jan de Nul	2022	EU	Yes	5000	3	167	0
34	Voltaire	Jan de Nul	2022	EU	Yes	3000	3	187	3
35	Vole au Vent	Jan de Nul	In operation	EU	Yes	1500	1	140	1
36	Maersk supply 1	Maersk	2026	US	Yes	3000	3	189	3
37	DLS4200	NPCC	In operation	EU	Yes	3810	3	-	0
38	tbd	Obayashi	2023	ASIA	Yes	1250	1	-	0
39	Taillevent	Oceanrich	In operation	ASIA	Yes	1000	0	-	0
40	BT220IU	OIM Wind	2026	EU	Yes	2600	2	165	3
41	Serooskerke/Walcheren	OOS	In operation	EU	No	2200	2	82	0
42	tbd	Penta-Ocean	2022	ASIA	Yes	1600	1	140	1
43	CP-80017	Penta-Ocean	In operation	ASIA	Yes	800	0	-	0
44	Saipem 7000	Saipem	In operation	EU	No	14000	3	-	0
45	Saipem 3000	Saipem	In operation	EU	Yes	2177	2	-	0
46	LTS 3000	Sapura	In operation	EU	Yes	2722	3	-	0
47	Sapura 3500	Sapura	In operation	EU	Yes	3500	3	-	0
48	Gulliver	Scaldis	In operation	EU	Yes	2300	2	77	0
49	Rambiz	Scaldis	In operation	EU	Yes	1750	1	77	0
50	Seajacks Scylla	Seajacks	In operation	EU	Yes	1500	1	153	1
51	Seajacks Zaratan	Seajacks	In operation	EU	Yes	600	0	119	0
52	Alfa Lift	Seaway 7	2022	EU	Yes	3000	3	108	0
53	Alfa Lift 2	Seaway 7	2025	EU	Yes	3000	3	108	0
54	Seaway Strashnov	Seaway 7	In operation	EU	Yes	5000	3	100	0
55	JU Ventus	Seaway 7	2023	EU	Yes	2500	2	177	3
56	JU VIND 2	Seaway 7	2025	EU	Yes	2500	2	189	3
57	Seaway Yudin	Seaway 7	In operation	EU	Yes	2500	2	79	0
58	Name tbd (4)	Shimizu	2022	ASIA	Yes	1250	1	179	3
59	Boreas	Van Oord	2024	EU	Yes	3000	3	190	3
60	Svanen	Van Oord	In operation	EU	Yes	5705	3	72	0
61	Aeolus 2.0	Van Oord	In operation	EU	Yes	1600	1	136,1	1
62	MPI adventure	Van Oord	In operation	EU	Yes	1000	0	120	0

Source: H-BLIX based on publicly available information.

Legend: Category FIV	
0	Able to lift foundations weighing < 1500t.
1	Able to lift foundations from cat. 1 (~1500t).
2	Able to lift foundations from cat. 1&2 (~2000t)
3	Able to lift foundations from cat. 1,2&3 (~2500t)

Legend: Category WTIV	
0	Insufficient lift capability
1	Able to lift turbine from cat. 1
2	Able to lift turbine from cat. 1&2
3	Able to lift turbine from cat. 1,2&3

CLV

The following table presents cable laying vessels (CLV) in operation and ordered.

Table 30 – List of CLVs in operation and ordered.

No.	Name	Operator	Delivery	Market	Able to enter Baltic Sea	Carousel [Te]
1	ariadne	Asso divers	In operation	EU	Yes	1500
2	atalanti	Asso divers	In operation	EU	Yes	4500
3	Constructor	Boskalis	In operation	EU	Yes	2000
4	Ndurance	Boskalis	In operation	EU	Yes	4500
5	ocean	Boskalis	2023	EU	Yes	4000
6	Spirit	Boskalis	In operation	EU	Yes	2000
7	edda freya	deep ocean	In operation	EU	Yes	3000
8	living stone	DEME	In operation	EU	Yes	10000
9	viking neptun	DEME	In operation	EU	Yes	4500
10	polar onyx	dong fang	2023	ASIA	Yes	2000
11	cs sovereign	global marine	In operation	EU	Yes	4600
12	Global Symphony	global marine	In operation	EU	Yes	2750
13	Normand Clipper	global marine	In operation	EU	Yes	4000
14	wave sentinel	global marine	In operation	EU	Yes	7800
15	tbd	High Tien	2024	ASIA	Yes	
16	Connector	Jan de Nul	In operation	EU	Yes	6000
17	Isaac Newton	Jan de Nul	In operation	EU	Yes	10500
18	Willem de Vlamingh	Jan de Nul	In operation	EU	Yes	5400
19	GL2030	LS	In operation	ASIA	Yes	8000
20	Connector	Maersk	In operation	EU	Yes	7000
21	Aurora	Nexans	In operation	EU	Yes	10000
22	skagerrak	Nexans	In operation	EU	Yes	7000
23	Victoria	NKT	In operation	EU	Yes	9000
24	Topaz installer	P&O maritime logistics	In operation	EU	Yes	3600
25	Cable Enterprise	Prysmian	In operation	EU	Yes	4000
26	Giulio Verne	Prysmian	In operation	EU	Yes	7000
27	Leonardo da Vinci	Prysmian	In operation	EU	Yes	17000
28	Ulisse	Prysmian	In operation	EU	Yes	7000
29	aimery	Subsea 7	In operation	EU	Yes	4250
30	Phoenix	Subsea 7	In operation	EU	Yes	4000
31	calypso	van Oord	2023	EU	Yes	5000
32	nexus	van Oord	In operation	EU	Yes	5000

Source: H-BLIX based on publicly available information.

LIST OF SOURCES (1/2)

Ref #	Document Name	Year	Organisation
Document			
[D1]	Global Offshore Wind Report 2021	2021	GWEC
[D2]	Global Wind Report 2022	2022	GWEC
[D3]	Offshore Wind Market Report: 2021 Edition	2021	NREL
[D4]	Study on Baltic offshore wind energy cooperation under BEMIP	2019	COWI, European Commission DG Energy
[D5]	Status of Offshore Wind Energy Development in Germany, Year 2021	2022	Deutsche WindGuard GmbH
[D6]	Offshore Wind Worldwide Regulatory Framework in Selected Countries	2022	Hogan Lovells International LLP
[D7]	Klimastatus og –fremskrivning 2022 (KF22): Havvind	2022	Danish Energy Agency
[D8]	Tuulivoimarakentamisen edistäminen	2021	Valtioneuvoston kanslia
[D9]	Installation Vessel Supply and Demand Update: Analysis to 2030	2021	4C Offshore
[D10]	Our Energy, our future, How offshore wind will help Europe go carbon-neutral	2019	WindEurope
[D11]	Regulation of the Council of Ministers on the adoption of the spatial development plan of internal sea waters, territorial sea and the exclusive economic zone in the scale 1:200 000	2021	Polish Government
[D12]	Regulation of the Minister of Infrastructure on the evaluation of applications in the adjudication procedure	2021	Polish Government
[D13]	Ten-Year Network Development Plan 2020, Main Report	2020	ENSTO-E
[D14]	A 2030 Vision for European Offshore Wind Ports, Trends and opportunities	2021	WindEurope
[D15]	The Declaration of Energy Ministers on The North Sea as a Green Power Plan of Europe	2022	
[D16]	How to accelerate permitting for wind energy?	2022	WindEurope
[D17]	Larger than life energy facts	2022	SGRE
[D18]	Offshore Wind Access Report 2020	2020	TNO
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[S2]	https://meriskenaariot.info/merialuesuunnitelma/en/legislation-and-guidance/	2022	
[S3]	http://mereala.hendrikson.ee/kaardirakendus-en.html	2022	Estonian MSP
[S4]	https://www.havochvatten.se/en/eu-and-international/marine-spatial-planning/swedish-marine-spatial-planning.html	2022	The Swedish Agency for Marine and Water Management
[S5]	https://sipam.gov.pl/geoportal	2022	
[S6]	https://www.renewableuk.com/news/news.asp?id=586952&hhSearchTerms=%22offshore+and+wind+and+cable+and+forecast%22	2021	Renewable UK
[S7]	https://www.spinergie.com/insights/offshore-wind-appetite-for-sovs-grows	2021	Spinergie
[S8]	http://ocean.dmi.dk/wavestat/index.uk.php	2022	Danish Meteorological Institute

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News items			
[N1]	https://windeurope.org/newsroom/press-releases/germany-gets-ready-to-deploy-more-than-10-gw-of-new-wind-per-year-with-historic-package/	2022	WindEurope
[N2]	https://balticwind.eu/latvia-rejects-orsteds-wind-project-the-government-wants-to-look-for-elwind-site/	2022	BalticWind.EU
[N3]	https://balticwind.eu/eolos-floating-lidar-solutions-will-perform-parameter-measurment-surveys-for-an-offshore-farm-in-lithuania/	2022	BalticWind.EU
[N4]	https://balticwind.eu/wind-turbines-in-finland-are-the-key-to-self-sufficiency-and-independence-from-russia/	2022	BalticWind.EU
[N5]	https://balticwind.eu/first-offshore-wind-power-research-permits-granted-for-finlands-exclusive-economic-zone/	2022	BalticWind.EU
[N6]	https://balticwind.eu/plans-to-speed-up-construction-of-offshore-wind-farms-emerge-in-finland/	2021	BalticWind.EU
[N7]	https://www.offshorewind.biz/2021/12/09/finland-sets-stage-for-offshore-wind-auction-in-2023-24/	2021	Offshore wind biz
[N8]	https://balticwind.eu/swea-permitting-phase-includes-67-twh-of-offshore-wind-potential/	2022	BalticWind.EU
[N9]	https://balticwind.eu/pl/szwecja-przyspiesza-rozwoj-energetyki-wiatrowej-rzad-przedstawia-pakiet-rozwiazan/	2022	BalticWind.EU
[N10]	https://balticwind.eu/the-industry-is-crying-out-for-offshore-wind-sweden-to-prepare-plans-for-offshore-wind-turbines-development/	2022	BalticWind.EU
[N11]	https://www.energyfacts.eu/deme-offshore-and-barge-master-develop-high-tech-feeder-solution-for-us-offshore-wind-farms/	2022	energyfacts.eu
[N12]	https://www.deme-group.com/news/demes-revolutionary-offshore-installation-vessel-orion-joins-fleet	2022	DEME
[N13]	https://www.offshorewind.biz/2021/07/06/jan-de-nul-orders-imeca-pile-gripper-for-les-alizes/	2021	Offshore wind biz
[N14]	https://wysokienapiecie.pl/70423-wszyscy-chca-budowac-wiatraki-na-polskim-baltyku/	2022	WysokieNapiecie.pl

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