Public

ISBN nr. 978-82-8368-074-4

Offshore Wind – Opportunities for the Norwegian Industry

Commissioned by Export Credit Norway

5/11/2020

THEMA Report 2020 - 13

About the project		About the report	
Project number:	EXP-20-01	Report name:	Offshore Wind – Opportunities for the Norwegian Industry
Project name:	Offshore Wind – Opportunities for the Norwegian Industry	Report number:	2020-13
Client:	Eksportkreditt	ISBN-number:	978-82-8368-074-4
Project leader:	Marius Holm Rennesund	Availability:	Public
Project participants:	Eivind Magnus David Konstantin Attlmayr Sigmund Kielland Arild Bolsø Magnus Sletmoe Dale Tor Inge Vevatne Leon Notkevich	Completed:	6/11-20

About the project consortium

THEMA Consulting Group Øvre Vollgate 6 0158 Oslo, Norway Company no: NO 895 144 932 www.thema.no	THEMA Consulting Group is a Norwegian consulting firm focused on Nordic and European energy issues, and specializing in market analysis, market design and business strategy.
The Renewables Consulting Group (Nordic) -RCGN	RCGN is the Nordic alliance between The Renewables Consulting Group (RCG) and ÆGE Energy. The consulting firm specialises in Management Consulting, Technical Advisory and Market intelligence services solely within the Renewable Energy sector.
Multiconsult	For more than 40 years, Multiconsult has been a leading provider of multidisciplinary expertise to the global offshore industry. In close cooperation with major energy companies and the supplier industry, we have acquired a substantial understanding of complex projects offshore, nearshore and onshore.

Disclaimer

CONTENT

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

LIST OF ABBREVIATIONS

ABEX	Abandonment Expenditure
AC	Alternating current
CAPEX	Capital Expenditure
CfD	Contracts for Differences
CNOOC	China National Offshore Oil Corporation
DC	Direct current
DEVEX	Development Expenditure
DoE	United States Department of Energy
EIA	United States Energy Information Administration
EPCI	Engineering, Procurement, Construction and Installation
GBS	Gravity-based support structures
GE	General Electric
HVAC	High voltage alternating current
HVDC	High voltage direct current
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
LCoE	Levelised Cost of Electricity
MSA	Maintenance and Service Agreement
NECP	National Energy and Climate Plan
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OHT	Offshore Heavy Transport
OPEX	Operating Expenditure
OnSS	Onshore substation structure
OSS	Offshore substation structure

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

OSW	Offshore wind
O&G	Oil and gas
O&M	Operations and Maintenance
PV	Photovoltaics
R&D	Research and Development
TIV	Turbine Installation Vessels
TLP	Tension-leg platform
TRL	Technology Readiness Level
TSA	Turbine Supply Agreement
UK	United Kingdom
US	United States
WACC	Weighted Average Cost of Capital
WBG	World Bank Group
WTG	Wind Turbine Generator

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

EXECUTIVE SUMMARY

Increased emphasis on climate policies, the phasing out of fossil power generation as well as targets for electrification and general growth expectations have led to a rapid growth in global demand for renewable energy. Combined with recent years' cost reductions and technology development, offshore wind is expected to become increasingly more important in the global power market. Based on expertise and experience from offshore operations both in Norway and internationally, Norwegian companies are well positioned to take significant market shares during the development, construction and operational phases for offshore wind farms, both regionally and globally.

Export Credit Norway asked the project consortium of Multiconsult, THEMA, and RCG Nordic to assess the long-term potential for the Norwegian supply chain within this fast-growing industry. This report addresses the following questions:

- What is the long-term global market potential for investments in bottom-fixed and floating offshore wind?
- What is the competitiveness and potential for Norwegian supply chain market shares within various parts of the value chain comprising offshore wind projects?

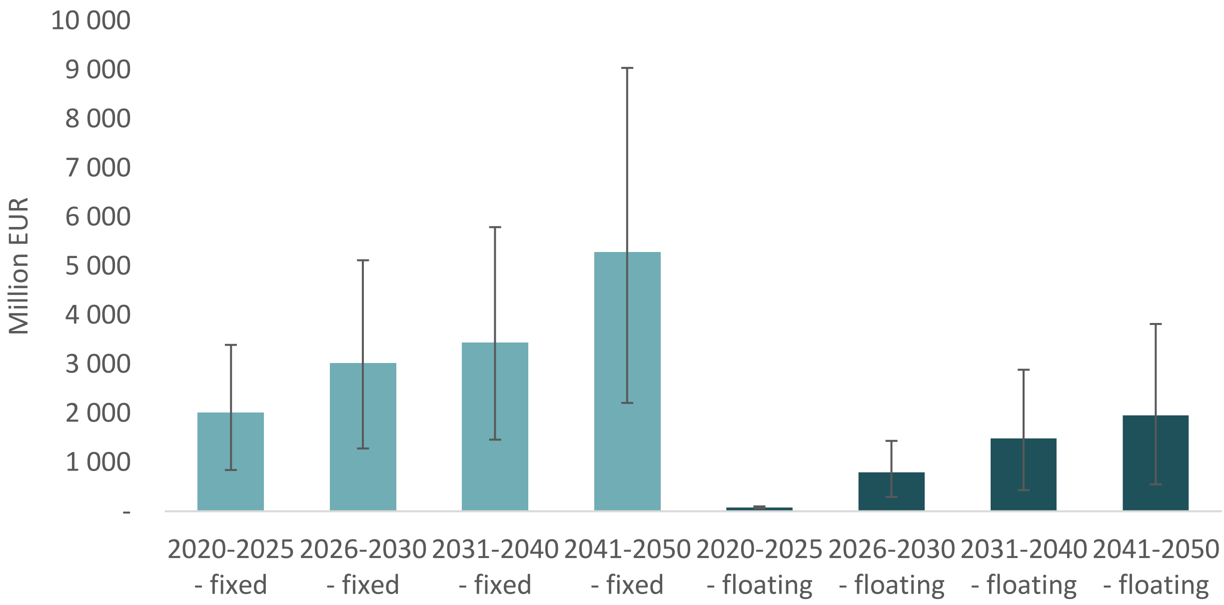
An expert group has analysed these questions separately for bottom-fixed and floating offshore wind technologies.

The expert group identified that the offshore wind industry has the potential to become one of Norway's most important export industries in the future. In the Base case scenario, turnover for companies registered in Norway for its activities in Norway and third-party countries in the offshore wind sector is forecast to 2.1 bn EUR/year in the near term to 2025, increasing to 7.2 bn EUR/year toward the end of the 2040s as depicted in Figure 1.

Due to uncertainties in market development, two additional scenarios have been developed to assess the potential turnover for Norwegian industry players in the global offshore wind market through to 2050:

In the Accelerated Growth scenario, we believe Norwegian players could capture up to 12.9 bn EUR/year by the end of the forecast period, where 3.8 bn EUR/year is achieved within floating offshore wind developments. Even in the Slow Progression scenario, we estimate that total turnover for the Norwegian supply chain could amount to 2.8 bn EUR/year in the same period.

Figure 1 Average yearly turnover for the Norwegian industry in the three scenarios Base, High Accelerated Growth and Low Slow Progression



THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

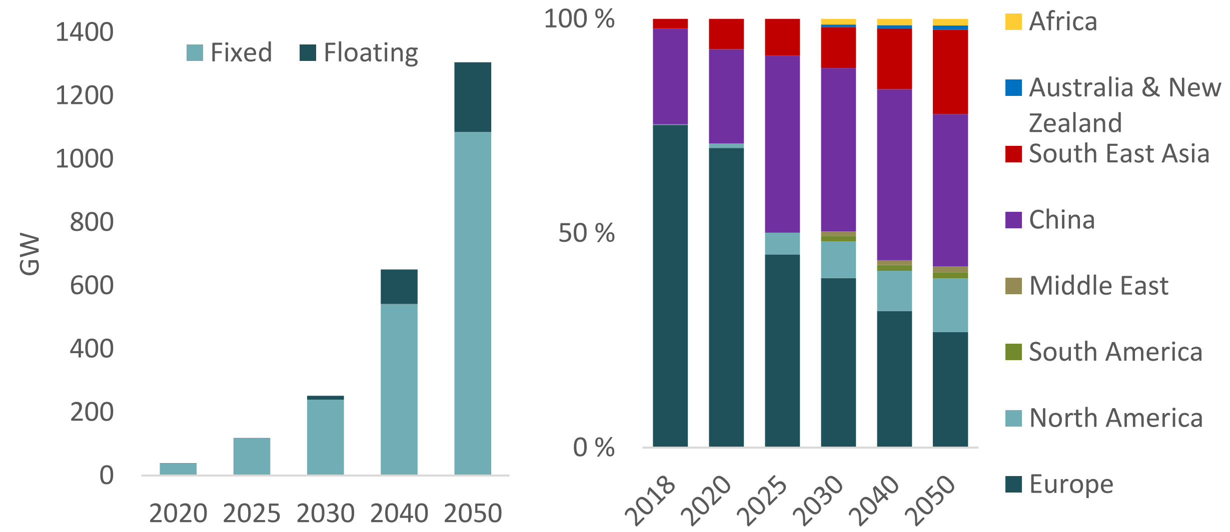
In the near-term, bottom-fixed offshore wind will remain the key source of turnover for Norwegian players, accounting for on average EUR 3 bn in the 5-year period from 2026 to 2030 and EUR 5.3 bn in the 2040s. Similarly, floating offshore wind makes up a mean of slightly below 800 MEUR/year in the 2026-2030 period and doubles to an average of almost 2 bn. EUR in the latter part of the analysis period. At the same time, the uncertainty around market development for floating offshore wind is high, and this will be highly influenced by national targets and policy making. In the accelerated growth scenario, deliveries to floating offshore wind could be high and offer great opportunities for the Norwegian maritime and offshore industries, which can develop solutions tailored to meet the challenges within offshore wind based on knowledge and experience from offshore oil and gas operations.

In the near term, the majority of turnover is still expected to come from the European market both for bottom-fixed and floating offshore wind, whereas other regions will become more important in the latter years as those markets develop. Europe makes up for a mean turnover of 2.7 bn EUR/year around 2030 and 3.7 bn EUR/year in the 2040s or 72% and 51% of the global turnover for Norwegian players.

Opportunities for Norwegian companies are particularly strong within installation of both turbines and floating foundations, project development and management, HVDC export cables and offshore sub-stations, array cables, as well as marine operations, mooring systems for floating wind farms and within operation and maintenance of offshore wind farms.

Figure 2 below shows our forecast for the cumulative installed offshore wind capacity per region from today until 2050 and the global distribution of offshore assets. Installed capacity is forecasted to increase more than six-fold over the next ten years and reach more than 1300 GW by 2050. A dominant European role in offshore wind will be met by the rapid expansion of offshore capacity in other regions, especially China. The rest of Asia and the US will also enter the offshore wind sector with high ambition levels from 2025 onwards. According to our estimate, offshore wind will cover almost 12% of global electricity demand by mid-century.

Figure 2 Total floating and bottom-fixed offshore wind capacity (left) and global capacity distribution per region & year (right)



Source: THEMA calculations

1 INTRODUCTION

Power production based on offshore wind is expected to become increasingly important in the global power market. Based on the expertise and experience from offshore operations both in Norway and internationally, Norwegian companies can be expected to capture a significant share of the global value chain from the development to construction and operation of offshore wind installations. In this report, we look at the long-term potential for the Norwegian supplier industry in the sector, by analysing two main questions:

- What is the long-term global market potential for investments in bottom-fixed and floating offshore wind power?
- What is the competitiveness and potential of Norwegian supplier companies within the various cost categories?

The report is written by THEMA Consulting Group, Multiconsult and RCG Nordic (RCGN). THEMA has been responsible for the forecasting of the market size based on RCGN's database of projects from 2020 to 2025 as well as providing context and background. An overview of the market segments and analysis of the key drivers for the market share has been explained by Multiconsult. RCGN has carried out an assessment of the opportunities for the Norwegian supply chain within each segment.

In the next paragraphs, the high-level structure of the report is described. Taking historical sector development of bottom-fixed and floating offshore wind and a forecast for their expansion over the next decades as a starting point, opportunities for Norwegian actors along the offshore wind value chain are analysed in the latter part of the report.

After an introduction with some of the main drivers for offshore wind build-out globally and the presentation of the methodology in this chapter, *Chapter 2 Market status and future potential of bottom-fixed offshore wind* discusses the historical development of bottom-fixed offshore wind, the more mature technology. It delves into the technological characteristics of bottom-fixed designs, the reason for cost decreases and then gives an outlook for the future capacity deployment in eight regions. *Chapter 3 The Formation of the Floating offshore wind sector and Future Potentials* follows a similar structure, but describes the floating offshore wind sector before drawing a comparison between the evolution of the two technologies. Following this, *Chapter 4 Segmentation of the value chain* gives an overview over how the value chain for offshore wind can be segmented. It presents main findings from key reports about the industry that show which parts of the value chain Norwegian suppliers are active in and where they can be successful going forward.

These descriptions and the expected sector expansion outlined in the first chapters form the basis for the expert assessment of opportunities for Norwegian actors along the value chain and a quantitative valuation of the revenue potential for Norwegian based companies that Norway could tap in *Chapter 5 Market potential for norwegian players in offshore wind*. Results are discussed drawing on the three scenarios called Slow Progression, Base Case and Accelerated Growth to sketch the impact different developments could have on the opportunities for the industry. For each segment RCGN have done a qualitative assessment of the Norwegian Supply Chains position as Dominant, Significant, or Moderate with a Norwegian market share ranging between High and Low, with Medium as an expected case. The scenarios used for this analysis are the Low value for Slow Progression, the Medium value for the Base Case, and the High value for Accelerated Growth.

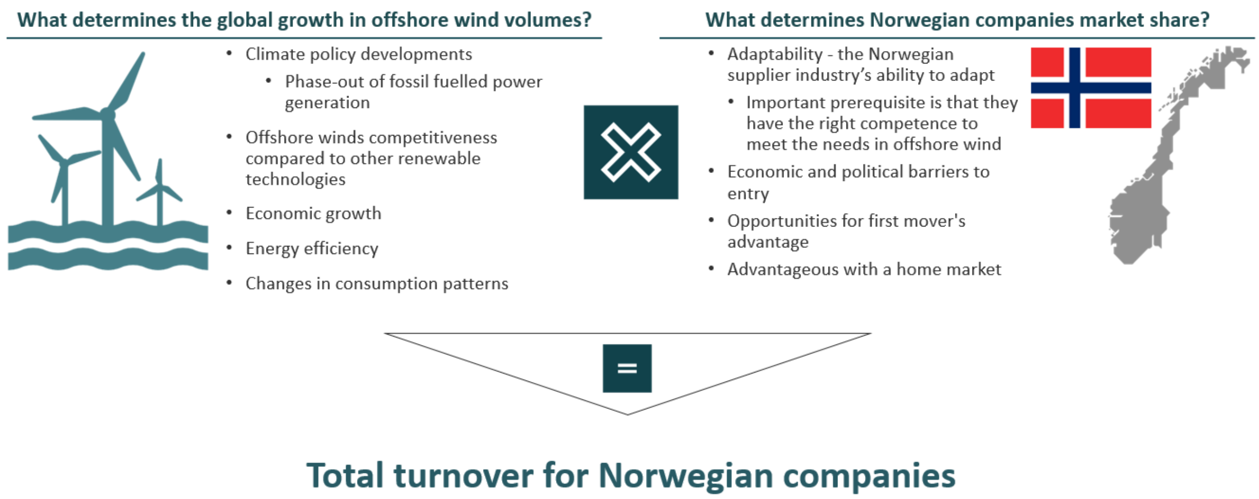
The segments are based on RCG's database which in turn are based on the contract structure of the market. *Appendix II – Offshore wind contracts features* a description of how a typical offshore wind contract is constituted as well as more detailed information on the reports that have been presented in *Chapter 4* and used in the assessment of the market potential for the Norwegian industry in *Chapter 5*.

1.1 Methodology

We will briefly describe the methodology used when analysing the two main questions outlined in the first paragraph. An overview of the methodology and main drivers can be found in Figure 3.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

Figure 3 Growth in global wind volumes and the Norwegian share of cost components determines the Norwegian turnover



Based on a description of recent developments in the bottom-fixed and floating offshore wind sectors, looking at technology and market developments, capacity additions, cost pathways and the political environment supporting the emergence of the offshore wind sector, we will look at the near- and long-term developments for both technologies. The latter offer more opportunities to the Norwegian industry due to a significant overlap of know-how from the offshore oil and gas and shipping industries.

For this work, we combine a top-down and bottom-up approach. The top-down approach will be based on the expected demand development for power in different regions in the world and an assessment of the market share for offshore wind. The demand developments are connected to economic growth, energy efficiency developments as well as climate policy, as stricter emissions target might lead to increased electrification. The expected market shares are strongly correlated with the cost developments of offshore wind technology compared to other forms of power production. We thus consider the relative production costs for offshore wind compared to other technologies and their development over time.

The bottom-up approach will build on a project database developed by Renewable Consulting Group (RCG), one of RCGN's two parent companies. Breaking down the aggregate market potential into different cost categories will help to develop a better understanding of the importance of each value chain segment and the scope of emerging opportunities for the Norwegian offshore industry. RCG's GRIP database tracks the development of offshore wind projects globally, recording project milestones and associated contracts. The data is sourced entirely from publicly available information, utilising official press releases and respected press sources.

The bottom-up approach is used for the short-term market development until 2025, while the top-down approach covers the subsequent period until 2050. We base the development up to 2025 on the existing offshore wind pipeline in the GRIP database and THEMA have then used aggregated numbers to make a top-down forecast for the period from 2025 to 2050.

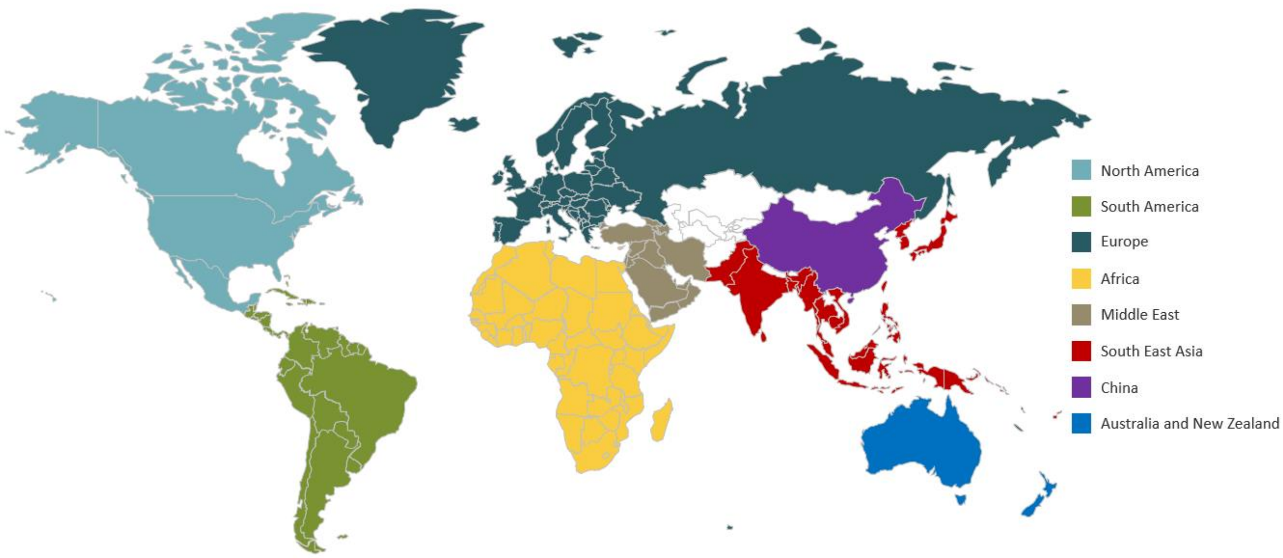
To better depict regional differences stemming from geographical and economic characteristics, the report divides the world into 8 regions.

- Europe including Russia
- North America
- South America

- The Middle East excluding North Africa
- China
- South East Asia
- Australia / New Zealand
- Africa

Economic power and suitable offshore wind conditions in each region will be a decisive factor for the build-out of large offshore wind capacities. An overview of the geographical differentiation is found in Figure 4. [1]

Figure 4 Regional differentiation for estimation of offshore potentials



Due to the significant uncertainties in technology and economic development but also political will, the global growth pathway of offshore wind is by no means guaranteed. However, increasingly ambitious climate policies of countries around the world, e.g. through the EU's Green Deal commitment to achieve carbon neutrality by 2050 and China's recently announced 2060 net zero target will require a massive expansion of renewable energy generation. As resistance to new onshore wind projects, especially in Europe, has shown, socially acceptable forms of the transition to clean energy provision must be found. Offshore wind can offer a less contentious alternative to harness wind power which underlines the important role of the technology in the world's future power mix. The offshore wind sector thus faces excellent starting conditions to thrive in the upcoming years.

In densely populated developed countries, offshore wind is often an already expanding sector. The countries surrounding the North Sea are an example for the early uptake of offshore wind parks although the economics of other forms of renewable power generation would favour their expansion more. The expectation of future cost declines supports the will to improve designs and further industrialise the sector to reap the benefits of affordable offshore power generation that will be needed to achieve decarbonisation objectives in the coming decades.

In contrast, sparsely populated regions as well as developing nations nowadays lack incentives to invest into more expensive forms of generation and will for the foreseeable future rely on cheaper forms of power generation, even when considering the need to transform their generation mix.

[1] We decided to include all Asian countries other than China as well as the island nations of Oceania in our "South East Asia"-labelled region.

With the groundwork being laid in Europe, however, diminishing expenditures for the construction of offshore wind farms will render them an increasingly competitive investment option in coastal regions across the globe that enjoy steady winds and have favourable, shallow waters.

Floating technology will have to be used in places such as Japan's east coast or the United States' west coast due to the seabed rapidly dropping off their coast. Even better wind conditions further out in the sea will also likely result in large capacity additions for floating wind in these regions. The dominant design of the technology is currently still being developed with wind farms smaller than 50 MW being developed and tested in Norway, France, the UK and Portugal. In Norway, Hywind Tampen is deploying eleven 8 MW turbines for commissioning in 2022. With the scaling of the industry, sizable cost declines can also be expected to materialise in the future. The prospect of combining the technology with "green" hydrogen production facilities adds another promising pull factor as well as offering cost reduction potentials due to potentially omitted grid connection expenses.

1.1.1 The short-term market size up until 2025

The build-out up to 2025 is based on RCG's GRIP project database (see Appendix IV for a detailed description of the GRIP database) which tracks the development of offshore wind projects globally, recording project milestones and associated contracts. It looks at individual projects rather than national or regional offshore wind installation targets and thus considers mainly the existing offshore wind pipeline with verified projects to be commissioned in the upcoming years.

However, the model does not account for the emergence of new project sites and new offshore wind markets as there are no reliable milestones from which the model can generate an accurate forecast. Up to 2025, the development of offshore wind parks in South America, Africa, the Middle East as well as in Australia and New Zealand seems to be unlikely with either only first preparations for the development of the sector happening at the moment or no planned projects on the horizon at all.

The GRIP database only includes projects announced by governments due to be leased to developers only where there are clear site parameters and the leasing process for the site has been confirmed by official government sources. That is neither the case in Australia, nor in the other abovementioned regions. We thus only forecast first capacity additions there after 2025.

Even though national or regional targets for offshore wind installation might exist, GRIP does not include them in the forecast, as offshore wind project site specific information is required.

1.1.2 The long-term drivers of offshore wind growth

In the longer term, the development of offshore wind will depend on politics, the market and the development of other renewable technologies. Although political targets have been set in major economies, significant uncertainties in technology and economic development but also political will persist, which means that the global long-term growth pathway of offshore wind is by no means guaranteed. The offshore wind sector faces excellent starting conditions to thrive in the upcoming years, but how strong it will grow will depend on:

- Climate policy developments
    - The phase-out of fossil fuelled power generation
- Offshore wind's competitiveness compared to other renewable technologies
- Economic growth
- Changes in consumption patterns
- Energy efficiency

Ambitious climate policy developments will foster more offshore wind

Increasingly ambitious climate policies of countries around the world, e.g. through the EU's Green Deal commitment to achieve carbon neutrality by 2050 and China's recently announced 2060 net zero target will require a massive expansion of renewable energy generation globally.

Decarbonisation will require replacing a large share of processes driven by the combustion of fossil fuels today to be provided through renewable energy sources. Among the existing renewable energy technologies, wind and solar power are the most promising to cover a large share in the energy transition,

As resistance to new onshore wind projects, especially in Europe, has shown, socially acceptable forms of the transition to clean energy provision must be found. Offshore wind can offer a less contentious alternative to harness wind power, underlining the importance of the technology in the world's future power mix.

Further, stronger climate policies also call for more electrification driving up the total demand for power. In our forecast we assume the emission targets as set out by the EU as well as national states across the globe will be met and that, leading to a gradual phase-out of fossil fuelled power generation capacity and is replaced by renewables including offshore wind.

Offshore wind's competitiveness compared to other renewable technologies

Offshore wind has over the past years shown a drastic decline in cost. Further cost decreases can be expected for both bottom-fixed and floating offshore wind. The growth in offshore wind will however largely be dependent on the relative cost developments for the technology compared to other renewable power generation technologies. A stronger cost decrease for offshore wind will make the technology more competitive and hence would trigger a higher share of offshore wind in the supply mix. Our assumed cost development is depicted in **Error! Reference source not found.**. Offshore wind is expected to be increasingly competitive compared other renewable technologies.

Economic growth and changes in changes in consumption patterns

Growth in economic activity has historically been coupled with increases in electricity use as populations grow and generate more goods and services. However, more recently this relationship decoupled in many countries. Most developed countries have been shifting from manufacturing economies toward service economies. Service-based economies tend to use less electricity than economies with high levels of industrial activity, as commercial services are generally less energy-intensive compared with manufacturing. Other countries like China, India, Brazil, and Egypt, have rapidly growing economies, often driven by a large or growing manufacturing sector. In these economies, we see a clearer relationship between economic growth and electricity demand growth. We assume economic growth in China to increase the power demand in the country significantly and that a significant share of the increase will be covered by offshore wind.

Energy efficiency

Energy efficiency measures in general lead to lower electricity demand, as we use less electricity for each unit of output produced. We do however see that further electrification leads to more efficient use of energy, as electrical engines are more efficient than engines running on fossil fuels. Energy efficiency measures might therefore lower electricity demand in already electrified sectors, but also lead to electrification of new sectors.

Multiconsult has provided an overview of different policy areas and how they impact offshore wind deployment in Chapter *5 Market potential for norwegian players in offshore wind*.

1.1.3 The long-term market size development

To arrive at the market size estimate from the period after 2025 until 2050, THEMA took recourse to its own modelling results for Europe and complemented them with energy outlook data from a thorough literature review. We took historical 2018 electricity demand as a starting point and compared different growth estimates, most notably from the IEA, the EIA and DNV GL, with our own forecasts to arrive at sensible annual growth rates for each of the above-mentioned regions out until 2050. The electricity demand levels serve as the basis for estimating the potential of offshore wind across the globe.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

For all regions other than Europe, we compared the share of offshore wind generation in total generation from the latest DNV GL Energy Transition Outlook with short-term forecasts for capacity targets in individual countries. Based on the expected capacity additions out to 2030, we adjusted the trend of offshore wind expansions to reflect recent increases in ambition levels, especially in Asia and the US. For Europe, we based the offshore forecast on the assumptions of our latest price forecast modelling results and combined them with DNV GL's shares in order to ensure a more consistent methodology. We resorted to this method also due to the fact that our modelling does not include parts of Eastern Europe which will likely see lower shares than our predictions suggest, mostly due to the region's differing economic situation and lingering political support but also due to the larger share of landlocked countries to the east.

This methodology led to the output of generation estimates for overall offshore wind generation for 2030, 2040 and 2050 for all eight regions. DNV GL's shares of floating offshore wind in terms of total offshore wind were then used to derive the generation share of floating technology. With a respective average capacity factor estimate of 45% for overall offshore wind capacity (fixed as well as floating) and 55% for floating capacity only, the total capacity per region for each of these years were calculated.

1.2 The market position of the Norwegian Supply Chain

Based on the identified aggregate market size as described above, RCGN assessed the Norwegian supply chain's competitiveness and potential to capture market shares in different geographical zones within each of the identified market segments. The analysis has captured the different phases of project Development (DEVEX), Construction (CAPEX), Operation (OPEX) and Decommissioning (ABEX).

Competitiveness and expectations of market shares will vary both in terms of the geographic zone and the different market segment. The market segments are based on typical offshore wind contract structures explained in *Appendix II – Offshore wind contracts* as well as the geographical location explained in Chapter 1.

RCGN have used the following three variables to evaluate the potential market share of Norwegian companies.

- Market Position
- Range (uncertainty)
- Sensitivities in future market development scenarios

Each of these variables have been described in more detail in the following sections.

1.2.1 Market Position

First, we have considered The Norwegian Supply Chain's market position for each segment with an expected market share we have called Dominant, Significant, or Moderate.

Each market segment has received a score of Nil, Moderate, Significant, or Dominant. These have been defined as follows.

Moderate

By a Moderate market share we mean a situation where Norwegian suppliers are present in the market, but typically would take a Tier 2 role as sub-suppliers. For bottom fixed, we have indicated a range between 0% and 5 %, whereas for the floating market we have defined the range between 0% and 10%. The P50 value is set at 2.5% for bottom fixed and 5% for floating.

Significant

A Significant market share means that the supplier or group of suppliers are among the top 5 suppliers in the industry. For bottom fixed, we have indicated a range between 5-15 %, whereas for

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

the floating market we have defined the range between 5% and 25%. The P50 value is set at 10% for bottom fixed and 15% for floating.

Dominant

A Dominant market share indicates a leading position for the Norwegian supply chain. For bottom fixed, we have indicated a range between 10% and 30%, whereas for the floating market we have defined this range between 15% and 45%. The P50 value is set at 20% for bottom fixed and 30% for floating.

Nil

Nil means that we have not identified any notable possibilities within the segment or market. Some market segments are considered to be out of reach for Norwegian companies. One example of this is the supply of wind turbines (33.6% of total market), which is dominated by a limited number of players in a few countries. Another example is the entire offshore wind market in China (34.6% of total market) which is considered impenetrable for non-domestic suppliers apart from rare anecdotal examples. Although RCGN have not seen signs of participation of non-domestic companies in the Renewable industry in China it is worth nothing that Aker Solutions have won contracts in both the Lingshui and Liuhua offshore oil fields in China for the China National Offshore Oil Corporation (CNOOC) with a total contract value above 2 bn NOK. We have also seen signs of Norwegian supply to the Wind Turbine market although we expect this to be too small to include this segment even with a moderate position. These two segments combined constitute 56.6% of the total fixed and floating global offshore wind market. Given the enormous size of the Chinese and wind turbine market there is potentially a very large upside for the Norwegian supply chain should it be successful with its endeavours towards China and/or towards international turbine manufacturers.

The considered market position for each segment is summarised in Appendix I - Methodology: Assessment of Norwegian market shares in global offshore wind sub-sections 7.3.1 Bottom-fixed offshore wind and 7.3.2 Floating offshore wind.

1.2.2 Range for each Market Position

The Norwegian Supply Chain had a turnover in the global OSW market in 2019 totalling 11 billion NOK. During 2019, 2.7 GW were commissioned, and 3.1 GW entered into construction. This translates roughly to a market share of ca. 10 %.

The expected market share (P50) is our best guess of what the market share within a certain segment could be. As there is uncertainty in the qualitative assessment of market shares, we have included a range, using a Low estimate (P30) and a High estimate (P70).

We have assumed different P50, P30 and P70 values for the bottom-fixed and floating wind markets. The Norwegian Supply Chain has a significantly stronger position in floating offshore wind compared to bottom fixed offshore wind, mainly as a result of early involvement in the Hywind Scotland and Hywind Tampen projects. Due to the immaturity of the floating wind industry, Norwegian companies have a unique chance of taking leading positions in this market.

Subsequently, floating offshore wind has a higher base assumption for each market segment and the range is more uncertain, and more dependent on policies and speed to market. RCGN has therefore considered these two related industries separately using the same methodology, but with different base assumptions and sensitivities. Our assumptions are presented in the below tables.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

Table 1 Estimated market share bottom-fixed OSW

Market Share	Base (P50)	Low (P30)	High (P70)
Nil	0	0	0
Moderate	2.5 %	0%	5%
Significant	10%	5%	15%
Dominant	20%	10%	35%

Table 2 Estimated market share floating OSW

Market share	Base (P50)	Low (P30)	High (P70)
Nil	0%	0%	0%
Moderate	5 %	0%	10%
Significant	15%	5%	25%
Dominant	30%	15%	45%

The results from our competitive assessment have been presented for each market segment in each geographical region, for both bottom fixed and floating offshore wind, with sensitivities around the pace of offshore wind deployment (see scenarios in the following section).

1.2.3 Market development

Base case

In the base case scenario, the two areas Southern North Sea II and Utsira North are being developed as announced, and sufficient policies are in place to allow projects to go forward. Project areas are awarded in 2021, the first licenses are given final award in 2024 and the first projects may be in the water by 2027. The onshore grid is developed to provide necessary capacity. Sufficient interest and funding are achieved to establish an emerging supply chain for floating offshore wind. Spending in the O&G industry continues to fall. Lastly, spending in renewable technologies continues according to stated plans in the Norwegian Supply Chain.

Accelerated growth

In this scenario, offshore wind deployment is happening quicker than anticipated in Norway, with larger volumes than already announced, and the first projects are in the water well ahead of 2030. Policies are put in place that accelerate supply chain development, which would strengthen the Norwegian supply chain's position on the world stage. The Nordic power price follows the high trajectory due to accelerated electrification and a slow-down in deployment of onshore renewables. After 2030, further floating wind projects are being developed in conjunction with O&G fields, or other innovative initiatives such as offshore carbon capture and storage or hydrogen production. Offshore wind farms are becoming part of a wider offshore grid allowing for interconnection and secondary routes to market. The O&G supply chain and maritime sectors have been able to transform skill sets and technology adapted to offshore wind. As a result, the Norwegian supply chain has been successful in acquiring market shares also outside of Norway. The outcomes of these events are thought to have a bigger impact on floating technologies than the bottom-fixed market, which is more established.

Slow progression

In this scenario, offshore wind deployment is going slower than anticipated due to low and delayed electrification of the transport and industrial sectors, resulting in continued low energy prices in the Nordics. Insufficient onshore grid capacity remains a blocker for project implementation. The first offshore wind projects are only realised after 2030, with floating sites lagging behind. Technology development is going slower due to uncertain market size and policies, as well as lack of sufficient funding of demonstration projects. Activity in O&G persists, which results in less interest from investors and supply chain in the renewables business. Unexpected adverse events have a long-term detrimental impact on investments in new technologies in the Norwegian Supply Chain.

RCGN has assessed the impact of the Slow Progression and Accelerated Growth scenarios for each market segment. The immature floating market is more sensitive for the two scenarios; hence policy and the positioning of the Norwegian Supply Chain have a higher impact on the market share for the floating industry compared to the bottom-fixed industry. A complete overview of the impact assessment can be found in Appendix I - Methodology: Assessment of Norwegian market shares in global offshore wind in *subsection 7.4 Impact of Slow Progress and Accelerated Growth scenarios*. The impact distribution of Slow Progression versus Accelerated Growth is skewed towards Accelerated Growth with an upside from Accelerated Growth amounting to more than double of the adverse effect of Slow Progression for both floating and bottom-fixed market segments. This reflects RCGN's view that the Norwegian Supply Chain will under all scenarios take a large share of the global offshore wind market, but that significant growth can be achieved with a combination of initiatives from the Norwegian Supply Chain and government policies.

Table 3 Estimated impact in three scenarios bottom fixed OSW

Impact on Market Share	Base Case	Slow Progression	Accelerated Growth
No impact	0 %	0%	0%
Low impact	0%	- 1%	2.5%
Potentially large impact	0%	- 2%	5%

Table 4 Estimated impact in three scenarios floating OSW

Impact on Market Share	Base Case	Slow Progression	Accelerated Growth
No impact	0%	0%	0%
Low impact	0%	- 1.5%	4%
Potentially large impact	0%	- 3%	8%

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

1.2.4 P50 & Sensitivities – High Accelerated Growth and Low Slow Progression

Finally, RCGN has defined three scenarios for the development of the Norwegian supply chain, based on a combination of the above variables. The actual trajectory and outcome will depend on both the Norwegian supply chain's ability to establish a footing in the market, and the development of policies, targets and frameworks from the local and central government bodies in Norway. The results of this analysis have formed the basis for the assessment of turnover presented in section 5.

RCGN has considered the impact of a Low Slow Progression and a High Accelerated Growth scenario for each market segment in each geographical region for both floating and bottom fixed offshore wind. The impact assessment for each segment is summarised in *7.4 Impact of Slow Progress and Accelerated Growth scenarios*.

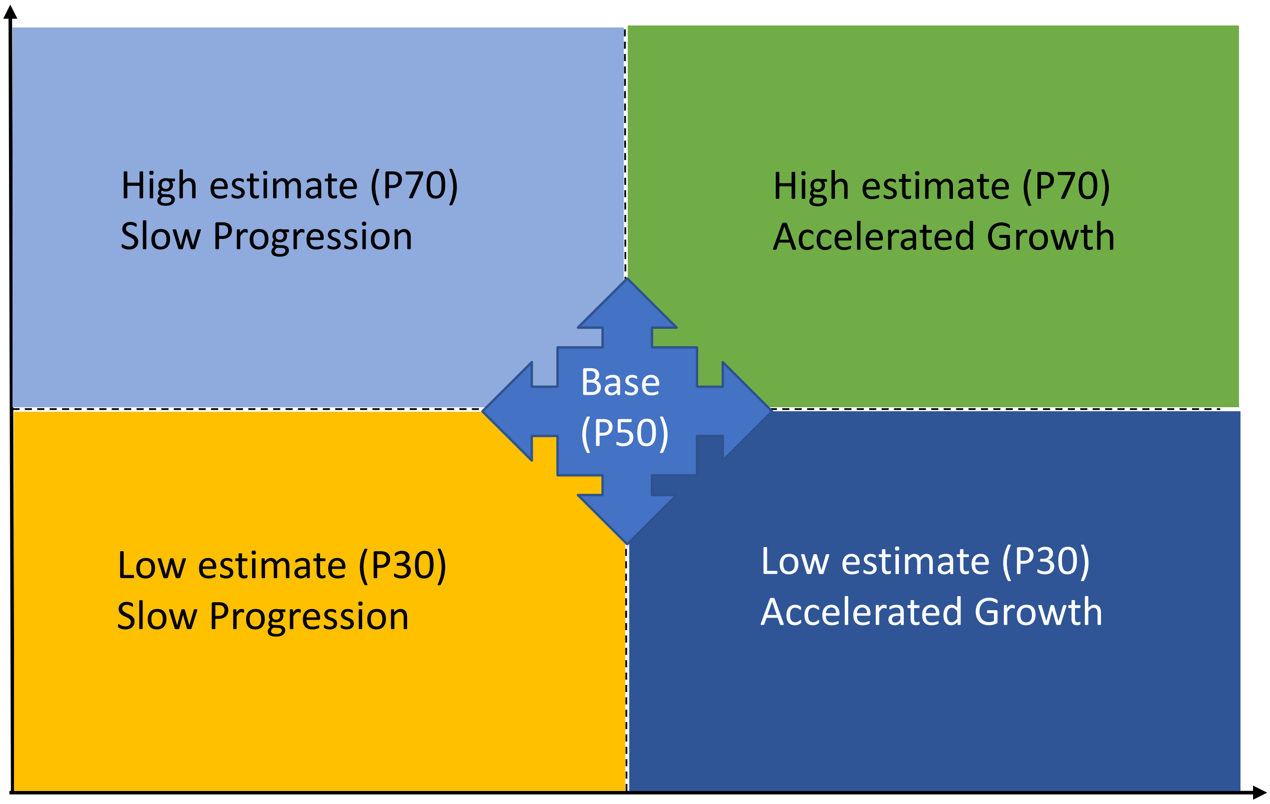
For this analysis, the Norwegian supply chain's position of Moderate, Significant or Dominant remain fixed while the range in market positions and the three scenarios are exchanged, thus creating five different outcomes. Three of these outcomes are analysed in this report summarised below:

1.) The Low (P30) value for the Moderate, Significant, and Dominant position is used for each segment under the Slow Progression scenario. This outcome is marked yellow in the bottom let corner of *Figure 5* Five outcomes from Slow Progression, Base Case, and Accelerated Growth scenarios with Low (P30), Medium (P50), and High (P70) Market Share estimates
2.) The Medium (P50) value for the Moderate, Significant, and Dominant position is used for each segment under the Base Case scenario. This outcome is marked by the blue middle arrowed square in *Figure 5* Five outcomes from Slow Progression, Base Case, and Accelerated Growth scenarios with Low (P30), Medium (P50), and High (P70) Market Share estimates
3.) The High (P70) value for the Moderate, Significant, and Dominant position is used for each segment under the Accelerated Growth scenario. This outcome is marked green in the top right corner of *Figure 5* Five outcomes from Slow Progression, Base Case, and Accelerated Growth scenarios with Low (P30), Medium (P50), and High (P70) Market Share estimates

These three outcomes represent the range of the analysis. The P70 Slow Progression (light blue top left corner) and P30 Accelerated Growth (dark blue bottom right corner) scenarios are excluded from the analysis as they represent middle scenarios within the outcome range of P70 Accelerated Growth and P30 Slow Progression.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

Figure 5 Five outcomes from Slow Progression, Base Case, and Accelerated Growth scenarios with Low (P30), Medium (P50), and High (P70) Market Share estimates



THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

2 MARKET STATUS AND FUTURE POTENTIAL OF BOTTOM-FIXED OFFSHORE WIND

Offshore wind has proven to be a promising complement to its onshore counterpart, especially in locations where land-based sites are limited, or resource availability is more favourable offshore. Generally, turbines installed offshore can harness wind at more stable conditions and at an increasingly competitive cost. Technological progress as well as the industrialisation of the sector are materialising in strongly falling project costs that lead to projections of cost-competitive offshore wind not too far in the future. The global market is expected to be dominated by Europe in the near term with the US, Asia and especially China seeing the emergence of sizable offshore wind sectors over time.

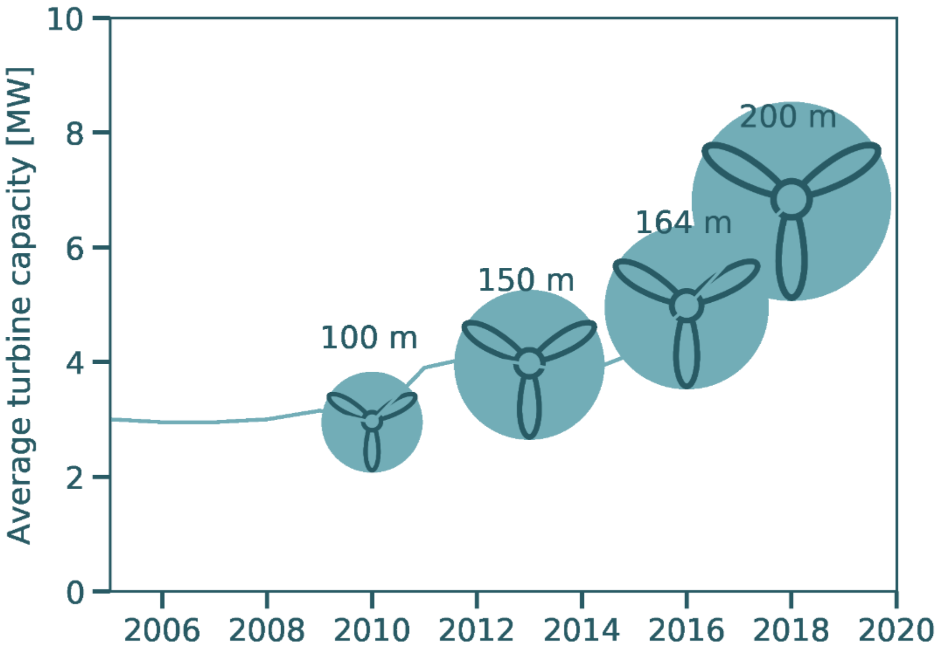
Offshore wind projects are more capital-intensive than their onshore equivalent, starting from higher installation costs, to greater operation and maintenance expenses and ultimately higher costs for decommissioning. The need for additional hardware in the form of substructures, subsea export cables and onshore/offshore substations results in a total CAPEX more than twice as high as that of an onshore project.

2.1 Historical development

2.1.1 Turbine size and rating has increased significantly

The increased deployment of offshore wind power has been accompanied by a gradual improvement of the technology. An indicator for the technological advancements is the increase in turbine sizes and ratings. As the sweep area of turbines increases, so does the normalised production hours with higher power output. While the first offshore turbines were built with a diameter of below 100 m, similar to that of onshore wind turbines at the time, new models reach diameters of more than 200 m (cf. GE's 12 MW Haliade-X turbine model at 220 m). Along with the rotor diameter, Figure 6 also shows the average rated power of turbines installed each year, which have increased from 3 MW to 6.8 MW between 2010 and 2019.

Figure 6 Historic average turbine rated capacity and rotor diameter worldwide



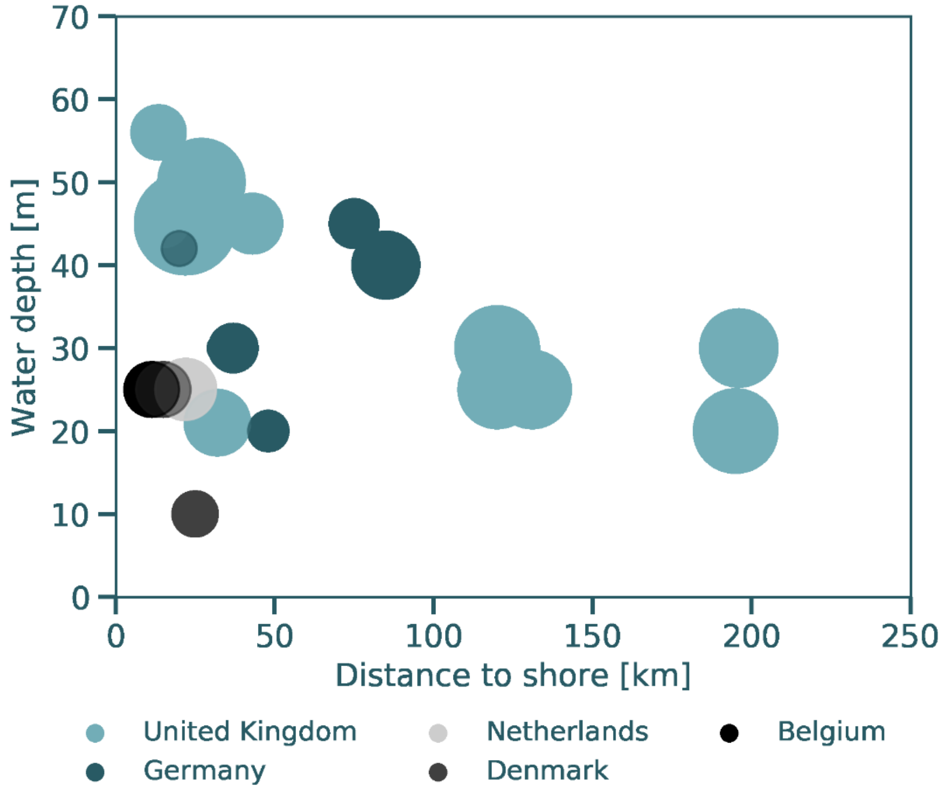
Source: THEMA (2020).

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

The development of more powerful turbines happened at a similar pace as for onshore wind technologies both in terms of turbine ratings and costs per MW. Another important development in the offshore wind industry is the substructure design, which should be equipped to withstand harsh weather and wave conditions, reach high water depths and function on different seabed surfaces. Historically, most wind farms were built at a distance of less than 50 km from shore at water depths below 40 m. Figure 7 shows the distance to shore and water depth of selected offshore wind projects in Europe. As projects moved into deeper waters, other substructure designs became the preferred choice:

- Monopile single steel pillars supporting the turbine on shallow waters
- Gravity-based concrete structures sunk to the seabed can be used at deeper water
- Jacket steel lattices as substructure for the turbine that can be used at even deeper water

Figure 7 Water depth and distance to shore for selected planned projects in Europe



Source: THEMA (2020).

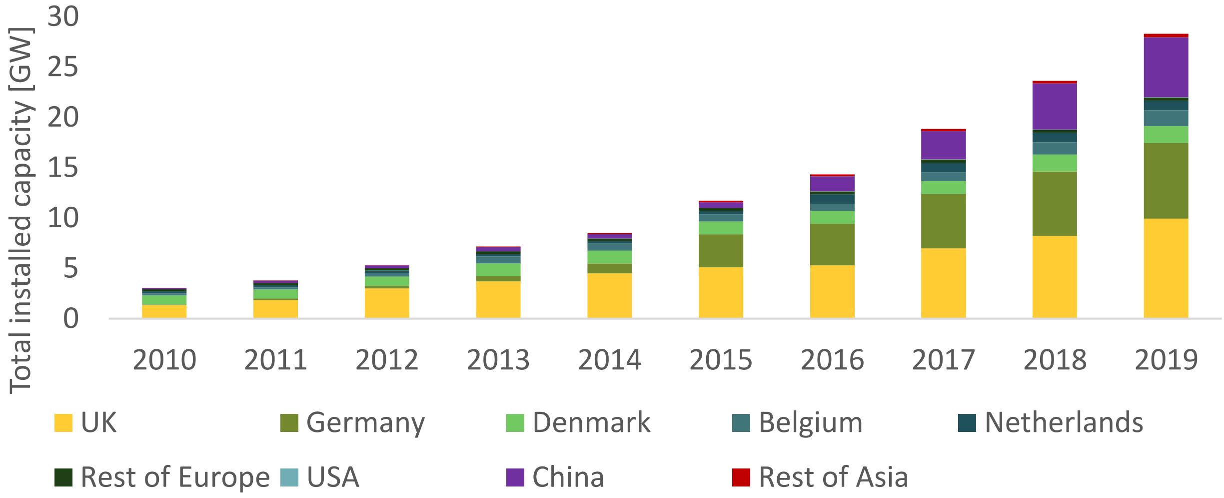
2.1.2 We have seen a steady increase in volumes

Globally, the large-scale deployment of offshore wind took off in the late 2000s with Europe being at the forefront of the technology's development. Denmark, the United Kingdom and Germany were among the first countries to operate offshore wind projects and have since then experienced a rapid increase in installed capacity. By the end of 2019, the cumulative installed capacity in Europe amounted to almost 22 GW of which 9.9 GW are installed in the UK, 7.5 GW in Germany, 1.7 GW in Denmark, and 1.6 GW in Belgium according to IRENA.

The only country outside of Europe that currently pursues large-scale offshore expansion is China with 5.9 GW by the end of 2019. Other Asian countries, namely Japan, South Korea, Taiwan and Vietnam, and the US are also venturing into the offshore wind sectors but have so far only added total capacities of around 100 MW or less. Project pipelines in the US and Taiwan, show that the rapid expansion of the sector within a short timeline.

The historic development of global offshore wind capacity is shown in Figure 8.

Figure 8 Total installed global offshore wind capacity (2010-2019)



Source: IRENA (2020).

2.1.3 Offshore wind costs are driven mainly by CAPEX costs

To give an overview, the main cost drivers for the LCoE of bottom-fixed projects are listed below.

Cost drivers of bottom-fixed offshore wind

- **Turbine Cost**: The wind turbine converts the kinetic energy of wind into electricity. The components of a wind turbine typically comprise the tower, rotor/blades, nacelle, generator, transformer, converters and associated electrical and mechanical equipment. The turbine cost makes up a significant share the total project cost. Larger WTGs has resulted in significant reductions in LCoE, which can be explained by fewer components and operations per MW installed capacity as well as higher capacity factors (full-load hours).
- **Substructure**: The substructure must be able to withstand the loads exerted by the wind turbine and the environmental conditions (e.g. wind, waves and tides). The cost for a fixed substructure largely depends on the concept (monopile, jacket or gravity-based structures), the water depth and seabed conditions.
- **Electrical System (Array cables, Offshore Substation Structure – OSS, export cables and onshore grid connection)**: The generation from the wind turbines is collected through array cables and transformed to higher voltage at the offshore substation for transmission to shore, where it connects to the main electricity grid. The main cost driver for the electrical system is the distance to the onshore grid connection point.
- **Operation and Maintenance**: The operational and maintenance expenses of an offshore wind project include the management of the plant, the inspection and servicing of the turbine and its components as well as all assets that are included in the balance of plant. OPEX costs are typically higher for offshore wind farms compared to onshore assets, as specialised vessels are needed. Again, distance from shore and local weather conditions are the most evident cost drivers.
- **Full-load hours**: The full-load hours are a measure of generation output from an offshore wind park. It describes how many hours the system would need to operate in full load to generate its total annual output. The generation output largely depends on the resource availability, i.e. wind speed at the site, but also accounts for downtime due to maintenance. In Europe full-load hours range between 3500-4500 with the best operational conditions found in the North Sea.

- **Lifetime**: The design lifetime of the system describes the period of time during which the system is expected by its designers to work within its specified parameters. Longer design life results in lower costs per generated unit of electricity, when viewed over the system's lifetime. The lifetime of an offshore wind farm is typically between 25 and 30 years, although individual components or systems may require replacement at specific intervals.
- **WACC**: The discount rate (weighted average cost of capital) for a typical renewable energy utility in Europe lies at 6 percent real before tax. Access to cheaper capital has been moving the market towards lower LCoE figures.

Since wind generation has a comparatively low OPEX due to the omission of fuel costs, CAPEX is the dominating cost factor for LCoE calculations. Financing cost can subsequently also have a large impact on the viability of the technology. On the generation side, good, steady wind conditions are determining the full load hours and hence the overall generation of the asset. Due to the importance of CAPEX cost, some of its main elements are explained in more detail below:

For a typical bottom-fixed offshore wind project, the turbine cost makes up approximately 45 % of the total investment cost. Other major costs are incurred for installation (15 %), substation (14 %), cabling (13 %) and the substructure (13 %) which are generally more site and technology specific (based on RCG's GRIP database).

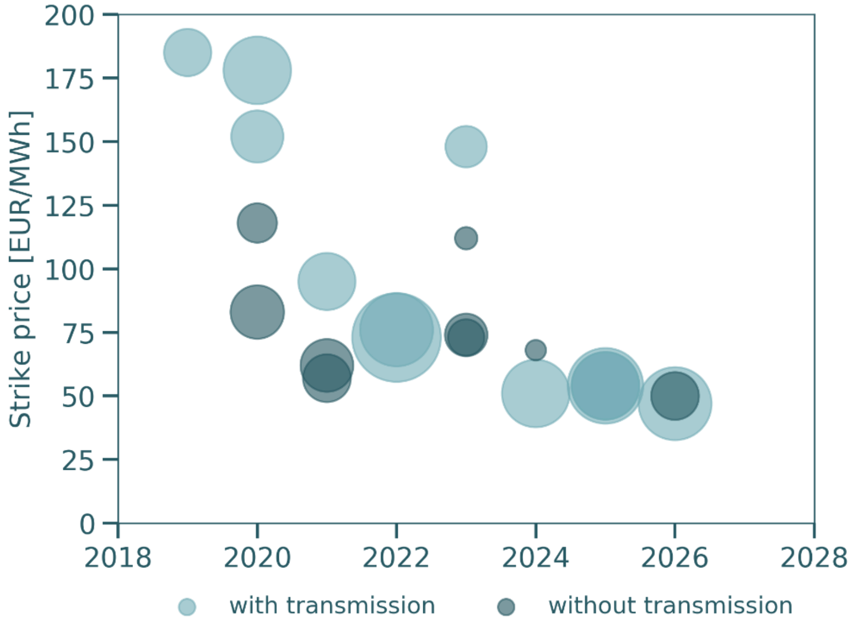
A major cost component in the installation of bottom-fixed offshore wind turbines is the use of specialised vessels. The installation of the substructures and turbines usually requires the use of specialised jack-up or crane vessels, sometimes also large floating vessels, of which only few are available today, and therefore command high day rates. Cabling is also associated with substantial costs for both the hardware and the use of cable-laying vessels. With improved, streamlined processes and technology cost reductions, installation costs have seen a significant decline in recent years. Although further decreases are expected, the overall potential for cost reductions is lower than for turbine and substructure manufacturing costs.

2.2 Project costs have fallen rapidly, and cost reductions are expected to continue

Looking ahead, further cost reductions can be expected for offshore wind power. The most important drivers behind the falling LCoE are larger wind farm sizes with more synergies and shared assets, larger turbines with increasing production hours in competitive auctions that have managed to introduce significant cost competition that in turn forces the market to choose new and cheaper technical solutions that drives down the costs.

Recent auction results for offshore wind projects in Europe have been successful in putting a cap on offshore wind farm cost and confirm the downward-sloping cost trend. Figure 9 shows the strike price for projects scheduled to come online in the next 7 years in the UK, Germany, the Netherlands and France. After 2022, projects with a varying degree of socialised transmission costs can reach a level of 50-70 EUR/MWh, which is less than half of the strike price for certain projects scheduled to be commissioned in 2020. In the last UK auction of 2019, strike prices for Contracts for Differences (CfD) even lay below the projected market price, hence the total subsidy budget was zero. While these results indicate that offshore wind costs are moving towards grid parity, it needs to be noted that in most countries, offshore wind still receive indirect subsidies such as reduced transmission charges. Even UK projects receive indirect price subsidies in form of a guaranteed price that facilitates more debt financing and thereby increased the return on the equity of the investor.

Figure 9 Strike prices for recent auctions for offshore wind



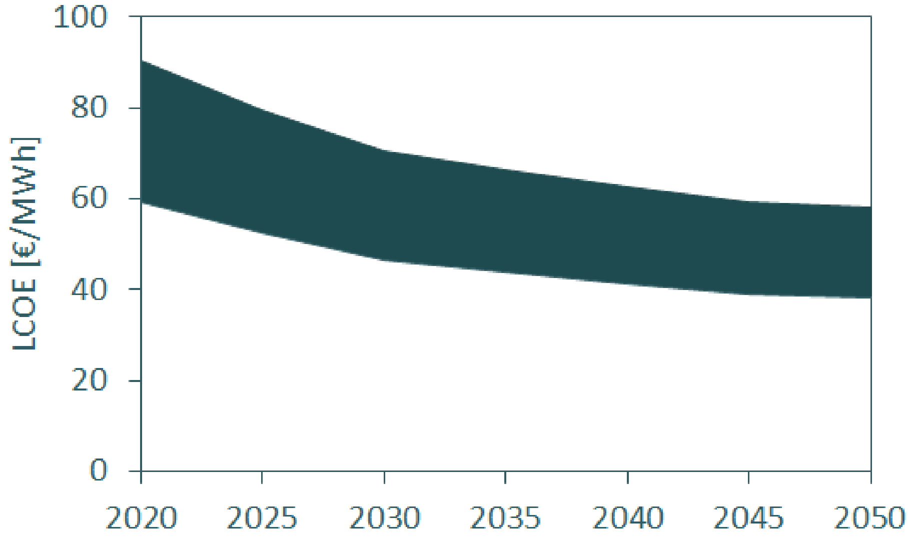
We expect the turbine price (per MW) to experience a continuing cost decrease as turbine ratings improve and production becomes more competitive. With offshore wind projected to become a key decarbonisation technology on global scale, the large demand for offshore turbines may however lead to short-term fluctuations in turbine prices. In the long-term, the demand increase will improve market competition and promote further price decreases. The large deployment of offshore wind is also likely to lead to a larger fleet of suitable vessels being available for installation and maintenance, putting downward pressure on CAPEX as well as O&M costs. Similarly, we anticipate that as a general trend, the cost for related components such as substructures and cables will decrease. Though, the total cost for cabling and substructures will depend on the site-specific requirements, as sites at low distance to shore and shallow water depths will be exploited first.

Figure 10 depicts our projections for the LCoE of bottom-fixed offshore wind. We expect the rapid decrease of the LCoE to continue over the next ten years. When a high level of offshore wind build-out is achieved, cost developments are likely to see similar trends to those previously observed for onshore wind. Specifically, once supply chains are established and economies of scale have pushed investment costs further down, additional cost decreases will stem from marginal improvements in performance or manufacturing.

A flattening of the LCoE in the long term is expected, reaching around 40-60 EUR/MWh. This is in line with conventional learning curve theory as initial learning translates into higher cost savings, and subsequent learnings result in increasingly slower, more difficult cost savings. As offshore wind is projected to become a key decarbonisation technology on global scale, the large demand will improve market competition and promote further cost reductions.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

Figure 10 Projections for the LCoE of bottom-fixed offshore wind in (real 2020 Euro)



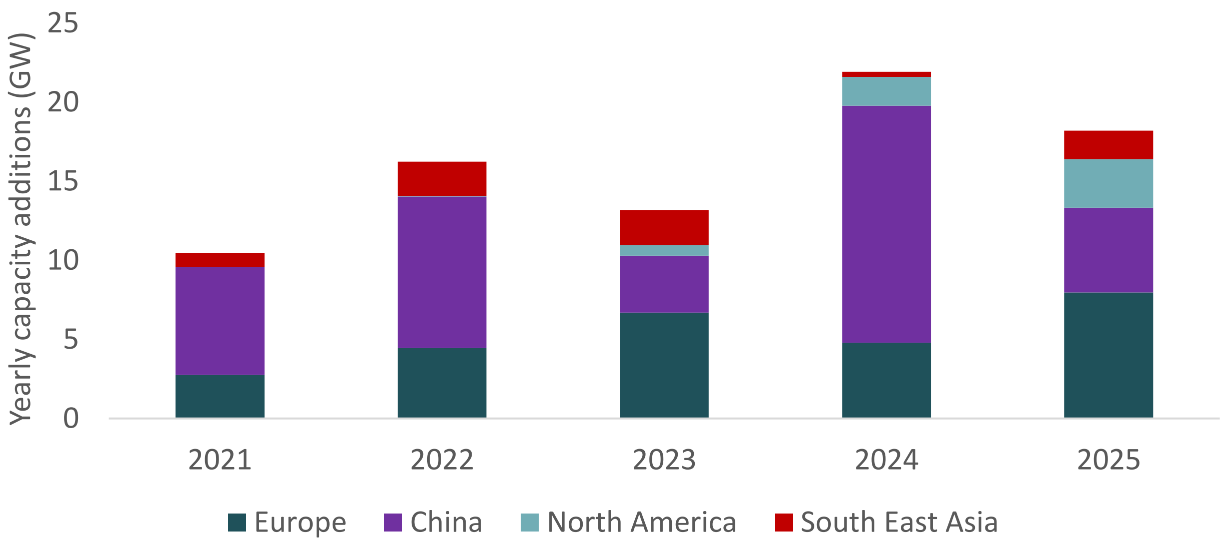
Source: THEMA Technology Outlook (2020). Best Guess scenario cost predictions.

2.3 Bottom-fixed offshore wind volumes will continue to grow

2.3.1 In the next five years, China and Europe will invest heavily in offshore wind

Main activities in the next five years are concentrated in the North Sea, the North-Eastern US, China and other Asian countries. These regions are early movers in the offshore wind sector due to good wind potentials and favourable coastlines, but mainly political support that helped the nascent industry to develop. Compared to Australia or Canada, the frontrunner countries rely on opportunities in offshore wind due to restricted land availability in densely populated coastal areas, whereas the main difference compared to regions such as Africa or South America are found in the economic strength to develop the sector and bring down costs for the next generation of offshore wind farms.

Figure 11 Annual global capacity additions of bottom-fixed offshore wind (2021-2025)



Source: RCG GRIP database (2020)

Yearly capacity additions until 2025 in Europe, North America, South East Asia and China are shown in Figure 11. As can be seen on the graph, Europe and China remain the dominant markets, while the growth in the US and other Asian countries is starting to pick up. According to the data from

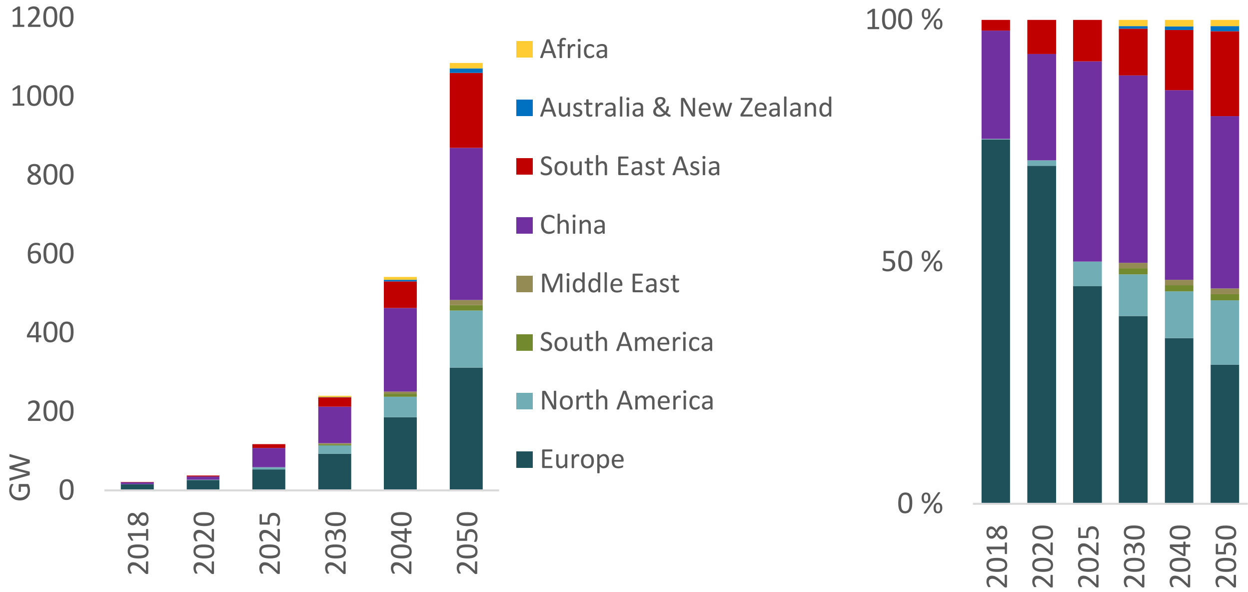
RCG's GRIP database, offshore wind capacity in China can catch up with Europe's cumulative capacity due to additions of more than 40 GW between 2021 and 2025. This brings both regions to total capacities of around 50 GW in the mid-2020s. Capacity additions in the US start picking up from 2022 and see more than 5.5 GW being added to the country's offshore wind capacity in 3 years. The additions in other Asian countries amount to almost 7.5 GW in the 5-year timeframe.

We do not expect any capacity additions in the remaining regions until the middle of the decade.

2.4 The bottom-fixed offshore wind sector has a remarkable outlook for the future

Based on the most likely development in the drivers above we arrive at the global distribution of bottom-fixed offshore wind as shown in Figure 12. A dominant European role with a global offshore wind market share of more than two thirds today is met by the rapid expansion of offshore capacity in China in the upcoming decade, but also the rest of Asia and the US to a lesser degree from 2025 onwards. Other regions, although often possessing large offshore wind potentials (e.g. South America with the highest regional potential of more than 6 TW according to a recent World Bank report [WBG (2020). Offshore wind development program]) will remain less important on the global stage even though they will also see their capacity growing by up to 20 GW by 2050. According to our estimate, offshore wind will cover almost 12% of global electricity demand by mid-century.

Figure 12 Overall bottom-fixed offshore wind capacity per region, year (left) and global bottom-fixed capacity distribution (right)



Source: THEMA calculations

2.4.1 Europe's ambitious climate change policy drives offshore wind expansion

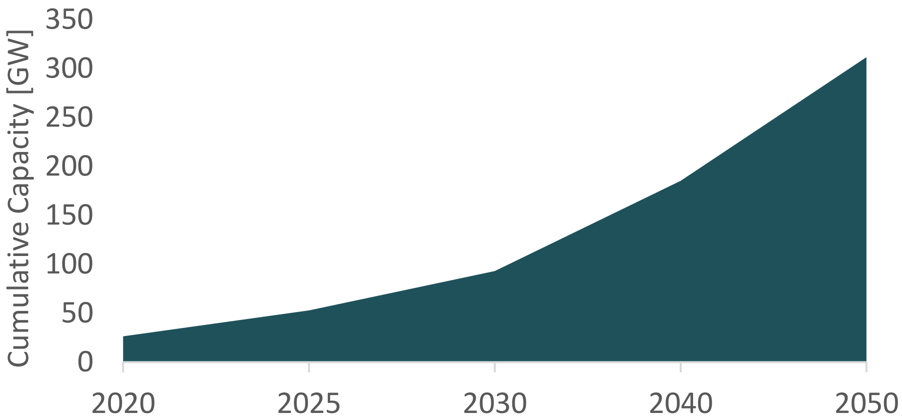
In Europe, we see offshore wind capacity having increased from 5 GW in 2012 to 11 GW in 2016 and more than 22 GW at the end of 2019.

Following announcements of the British government to build 40 GW and Germany for 20 GW of offshore wind by 2030, in addition to the targets of other North and Baltic Sea countries, a total capacity of more than 100 GW seems to be plausible by the end of the decade. The recent announcement of the EU Commission to increase the block's decarbonisation target from 40% to at least 55% supports a trend of ever-increasing ambition levels. With the objective to use the production of green hydrogen to decarbonise hard-to-abate sectors, offshore wind will be assigned a central role in meeting the power needs of such additional demand.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

As can be seen in Figure 13, the next decade will set a trend and already lead to a massive offshore expansion to arrive at a cumulative capacity of more than 90 GW. This is then expected to roughly double through 2040 to land at a total capacity of around 311 GW by 2050 corresponding to a generation of almost 1200 TWh.

Figure 13 Bottom-fixed offshore wind capacity development in Europe through 2050



The EU Commission's long-term decarbonisation strategy from 2018, which has to be re-evaluated after the recent increase in ambition, sees the need for 230-450 GW of offshore wind to achieve the requirements of the Paris Agreement. Our forecast thus falls slightly short of reaching the mean but remains decidedly higher than DNV GL's Energy Transition Outlook expectation of ca. 240 GW of bottom-fixed offshore wind by 2050. Since the Commission's target also includes floating offshore wind, the numbers in the subsequent chapter have to be added to the bottom-fixed volumes in order to see the whole picture.

In general, we believe that our results are justified given the recent push for higher targets as well as a string of announcements in several EU countries to elevate their respective offshore wind objectives.

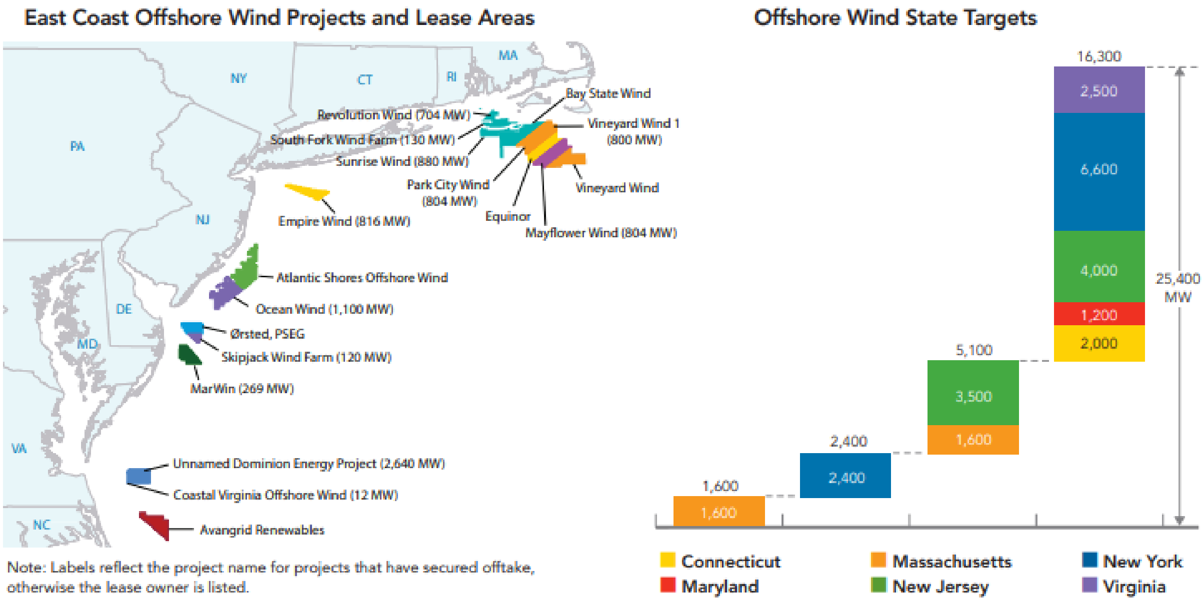
2.4.2 The Northeastern US plans to instil significant growth in the North American market

The story in North America is different to Europe insofar as the abundant land, especially in Canada, leads to a diminished need for the build-out of offshore assets. Only in the Northeast of the US, where recent years have seen high interest in the development of offshore wind technology, do concrete projects and state-level offshore wind expansion targets exist.

While the EIA's latest Annual Energy Outlook only sees offshore wind levels of 18 GW by 2050, 4.9 GW of capacity is expected to come online by 2024 and current state-level targets show 16 GW of new targets in 2019 alone, amounting to over 25 GW of offshore wind in the pipeline (cf. Figure 14). Contrary to the bearish expectations of the EIA, the DoE expects 30 GW of offshore wind by 2030 and 86 GW by 2050, all to be deployed on the East Coast, mainly in New York, New Jersey, Massachusetts, Virginia, Connecticut and Maryland.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

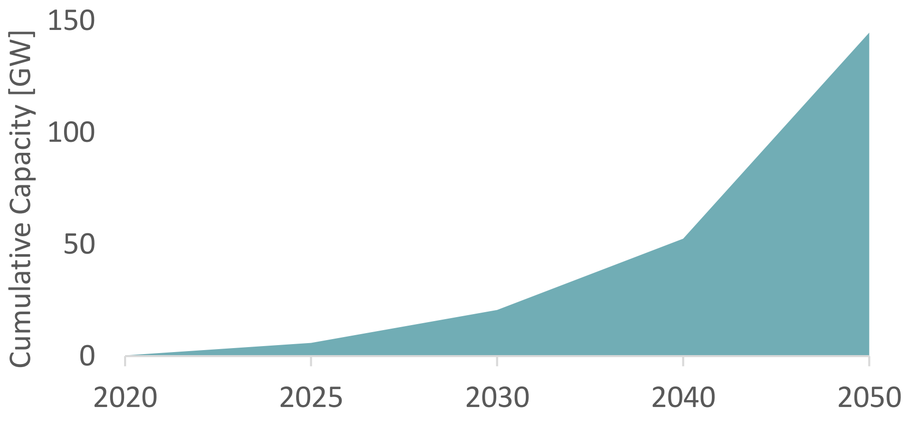
Figure 14 Offshore wind targets in the US in the upcoming years



Source: American Wind Energy Association (2020). Wind Powers America. Annual Report 2019.

With a bit of uncertainty regarding the realisation of the US pipeline, we arrive at a forecast of slightly more than 20 GW of bottom-fixed offshore wind in North America by 2030, mainly consisting of US assets. Figure 15 outlines the increase to about 52 GW in 2040 and a drastic expansion to almost 145 GW by 2050 when the most suitable areas in Canada and Mexico will additionally be exploited in pursuit of the energy transition. That amounts to a total output of around 550 TWh.

Figure 15 Bottom-fixed offshore wind capacity development in North America through 2050



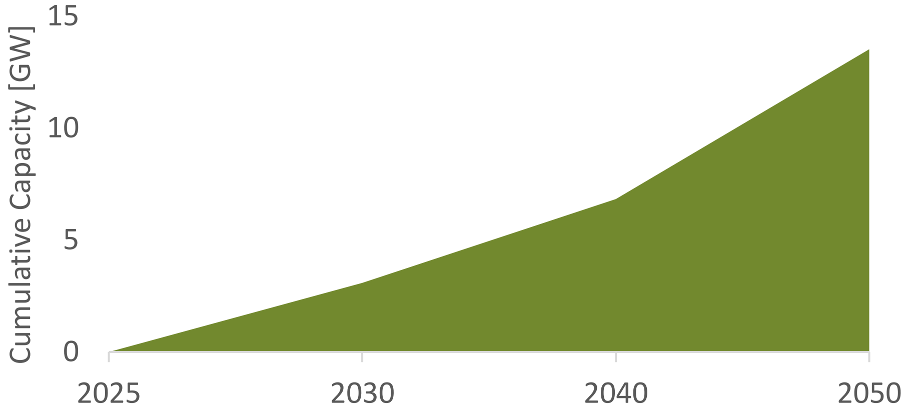
2.4.3 Despite large potentials, bottom-fixed designs will only slowly grow in South America

Giving an estimate on the future bottom-fixed offshore build-out of South America is difficult. Especially because firstly, no targets exist, and political instability does not provide a good investment environment for very CAPEX-intensive projects such as offshore wind.

However, the region has access to pristine wind resources and enjoys a long coastline, which can provide many opportunities for the expansion of offshore assets in the future. A World Bank study (2020) identified 6.3 TW of total technical potential in the region, which is higher than for any other region globally. While the area around the equator is not particularly prone to see installations due to low average wind speeds, Brazil, Argentina, Uruguay and Chile are well suited to host large amounts of future offshore wind capacities.

With our assumptions, we expect close to 14 GW of bottom-fixed offshore generation to be deployed by 2050 (see Figure 16).

Figure 16 Bottom-fixed offshore wind capacity development in South America through 2050

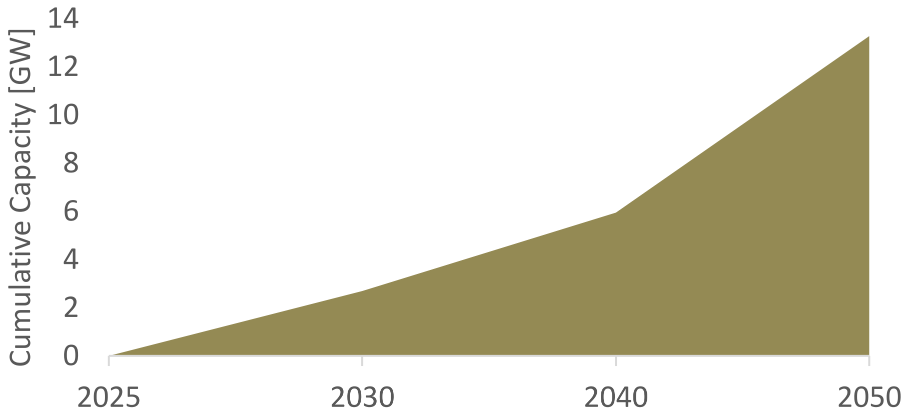


2.4.4 Uncertainties and lower wind resources will limit growth potential in the Middle East

Similar to some parts of South America, the proximity to the equator and associated low wind speeds act as a detrimental factor to the opportunities for offshore wind in the Middle East. More population centres in coastal areas, however, aid the case for the technology since parks can be situated close to them and do not require large connection efforts.

As can be seen in Figure 17 the development path of offshore wind in the Middle East is thus depicted in a similar fashion to the one in South America. The absence of concrete expansion targets in addition to the insecure future role of oil and gas result slightly less than 15 GW of bottom-fixed offshore assets. That adds up to almost 50 TWh in generation.

Figure 17 Bottom-fixed offshore wind capacity development in the Middle East through 2050

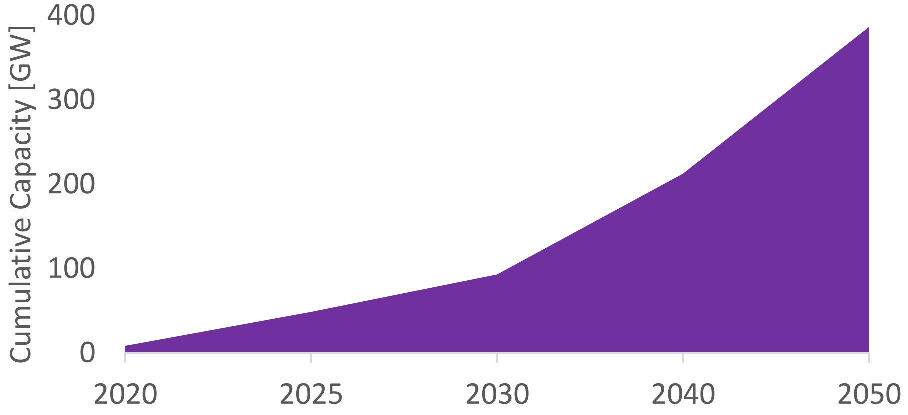


2.4.5 Chinese plans for the sector are ambitious and will result in large capacity build-out

Several forecasts, e.g. from WoodMackenzie, show that China will increase its capacity fivefold by 2030 from currently around 10 GW of offshore wind. This corresponds to government targets to reach up to 50 GW of offshore capacity to support China’s domestic turbine manufacturing industry. This would make China the country with the largest fleet ahead of the UK but falls still short of the expected offshore wind capacity build-out in the EU. In our forecast, the country would achieve that feat shortly after 2030 and end up at a bottom-fixed offshore wind capacity just shy of 400 GW by

2050 which translates into more than 1450 TWh of wind power generation. The development path of bottom-fixed capacity can be seen in Figure 18.

Figure 18 Bottom-fixed offshore wind capacity development in China through 2050

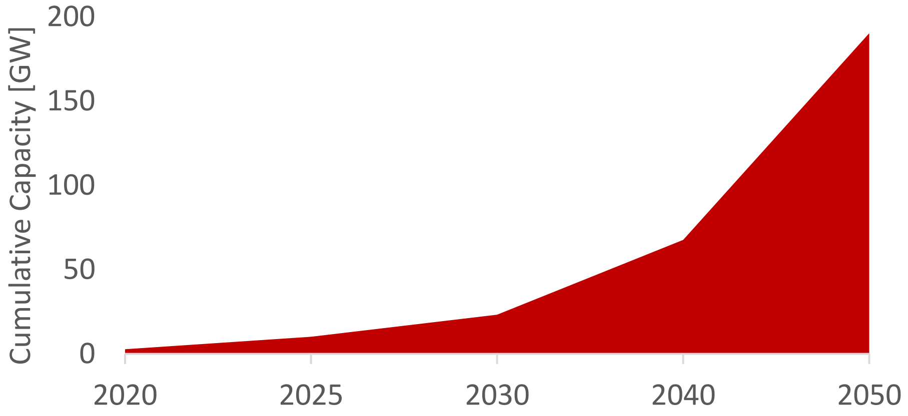


2.4.6 Several Asian countries pursue the large future potential of wind farms at sea

Not only China sees a large increase in offshore wind over the forecast period. Countries such as Taiwan, Thailand, Vietnam, India, Japan or South Korea all have huge ambitions to exploit their offshore wind potentials and have started to set government targets for 2030. According to official objectives, Taiwan wants to build 5.5 GW by 2025 and 10 GW by 2030, India 30 GW, South Korea 12 GW and Vietnam 6 GW, all by 2030. Japan has an unofficial target to achieve 10 GW by 2030 but project development in the island nation has so far been delayed.

Barring Japan's stalemate, the region's strong political determination has also found entry into our projected future offshore wind development. Figure 19 depicts offshore wind capacity rising from 24 GW of bottom-fixed designs in 2030 to ca. 190 GW by 2050.

Figure 19 Bottom-fixed offshore wind capacity development in South East Asia through 2050



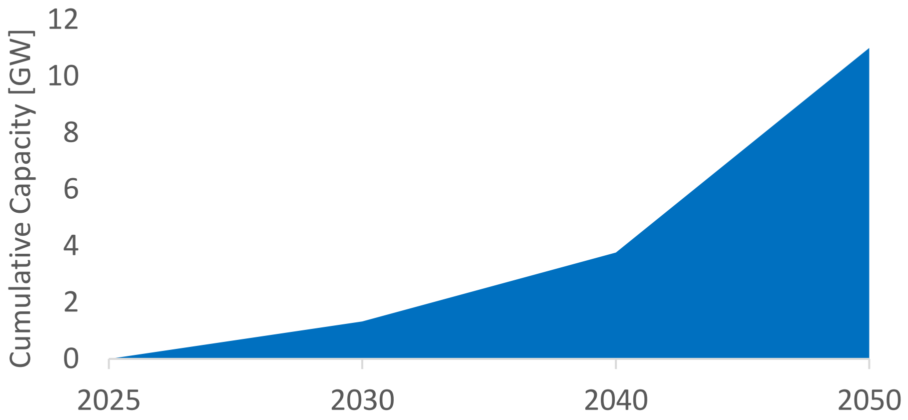
The region enjoys favourable conditions with many islands and good wind conditions leading to large offshore wind potentials. For example, the previously cited World Bank report sees the potential for offshore wind in Vietnam at 475 GW, with 261 GW for fixed and 214 GW for floating installations. Also, India's two regions Gujarat and Tamil Nadu alone have a potential of 106 GW and 60 GW respectively. Other countries enjoy similar environments. In addition, natural resource scarcity in South Korea and Japan will require these nations to draw up alternative solutions for their decarbonisation efforts, which might further benefit the future roll-out of offshore wind capacities.

2.4.7 Australia and New Zealand are comparatively late in developing the sector but will nonetheless see a large share of power coming from bottom-fixed offshore wind

First projects in Australia are already starting to see the light of day with ca. 3 GW of capacity in the pipeline, which are however currently expected to enter the market after 2025. The offshore wind market is still at a very early stage of development compared to other OECD countries. Even though the wind conditions in the Southern parts of both countries are well suited to the deployment of offshore wind, especially Australia's vast open spaces make onshore assets likely the preferred option throughout the time horizon.

New Zealand has also taken first steps into developing offshore wind capacity and looks to commission a first 200-800 MW project in the late 2020s.

Figure 20 Cumulative bottom-fixed OW capacity in Australia and New Zealand through 2050



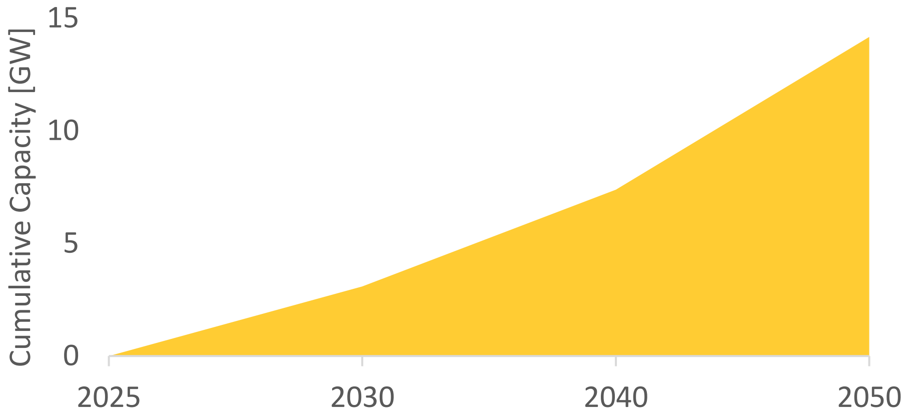
Since the region's total generation needs are much lower than that of the other regions in the report, Australia and New Zealand will only see offshore wind generation of around 50 TWh by 2050 in our predictions, stemming from a capacity of 11 GW fixed and a bit more than 2 GW floating offshore wind (cf. Figure 20). However, this covers almost 12% of total power demand and is only trumped by higher offshore wind shares in Europe and China.

2.4.8 Great conditions in some African countries are opposed by economic and political uncertainty

Africa does not see offshore wind generation today. However, given the good wind potentials in some areas, e.g. in Morocco, Tanzania, or South Africa (the World Bank estimates a potential of more than 350 GW), the sector is expected to emerge in the coming years.

The economic conditions and uncertainty for investors are playing a large role for conducting successful projects. The falling LCoE of offshore wind assets will still lead to a sizeable build-out in the most profitable locations and result in bottom-fixed capacity just below 15 GW by 2050, as shown in Figure 21.

Figure 21 Bottom-fixed offshore wind capacity development in Africa through 2050



THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

3 THE FORMATION OF THE FLOATING OFFSHORE WIND SECTOR AND FUTURE POTENTIALS

Europe is the first region to have installed full-scale floating offshore wind capacity, albeit currently mainly as pilots to gain experience with the technology and associated challenges. Floating wind projects can expect even faster cost decreases than bottom-fixed technology, albeit from a higher starting point. The technology opens up many coastal regions with larger water depths to wind power generation. The potential deployment is thus expected to increase strongly as soon as first significant cost reductions have been achieved.

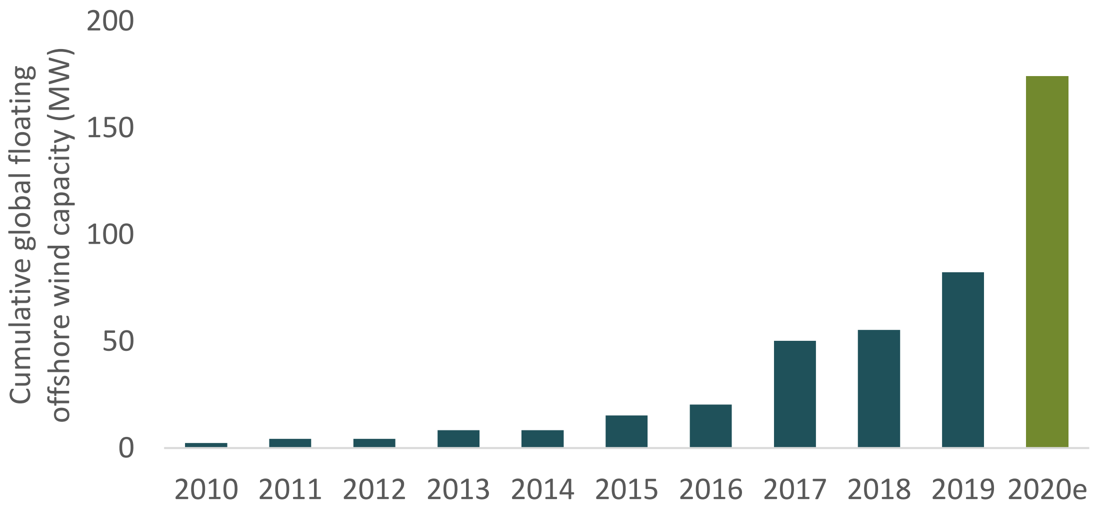
3.1 Historical development of the floating offshore wind sector

While bottom-fixed projects may only be economically attractive at water depths of less than 60 meters, turbines on floating substructures can be placed at sites with favourable wind conditions at greater water depths. A large majority of locations suitable for offshore wind deployment are in areas with water depths of more than 60 meters. Floating offshore wind thus has great potential, but faces more uncertainty related to technology and cost development, which results in a more uncertain market potential.

Since the first full-size floating operational offshore wind turbine was deployed off the coast of Norway in 2009, several pilots have been commissioned, mainly in Europe. In 2017, the first larger-sized floating offshore wind farm pilot came into operation off the shore of Scotland. Since then, a range of European markets including France, Norway, Portugal, Spain and the UK have announced pre-commercial floating offshore wind projects to be commissioned over the course of the next 3-4 years.

Currently, these are also the main markets for floating offshore wind globally, all profiting from good offshore wind conditions in the vicinity of industrial demand along their coastal areas. According to WindEurope, 75% of floating offshore wind projects under development are led by European developers. Other markets such as South Korea, Japan and the US could also expect a rapid ramp-up of floating offshore capacity due deeper sea levels close to the coast that prevent bottom-fixed designs from being deployed. In particular, Japan has seen first pilots and larger project announcements, with the other two countries soon expected to follow. It is also in these markets where floating offshore wind is close to complete pre-commercial phase development, as the technology is now ripe for commercialization and scaling.

Figure 22 Historical global floating offshore wind deployment (2010-2020)



Source: Floating Wind JIP Phase 2 Summary Report (2020);

**2020 numbers also include Kincardine project expected to be finished before the end of the year*

Figure 22 shows the development of floating offshore wind capacities in the last ten years. While only small-scale pilots have been conducted until 2017, the sector has since managed to more than double. And the existing pipeline shows that ever larger projects are being prepared for commissioning. For example, the market in Europe is now moving to larger projects over 200 MW.

This is also reflected in the individual turbine size: The 2.3 MW Hywind turbine was superseded by 5 MW and 7 MW turbines in the Fukushima FORWARD project in Japan as well as an 8.4 MW design for the WindFloat project off the coast of Portugal that was connected in the beginning of 2020. The 50 MW Kincardine project expected to be commissioned by the end of the year will host five 9.5 MW offshore wind turbines. This increased size in turbines deployed on floaters does not only boost power generation but is a key driver for cost reduction.

Table 5 below shows a selection of announced floating offshore wind projects.

Table 5 List of floating offshore projects with announced COD to date

Market	Project	Size (MW)	Announced COD
Norway	Hywind Demo	2.3	2009
Portugal	WindFloat	2	2011
Japan	Kabashima	2	2013
Japan	Fukushima FORWARD	2	2013
Japan	Fukushima FORWARD	7	2016
Japan	Fukushima FORWARD	5	2017
UK	Hywind Scotland	30	2017
France	Floatgen	2	2018
Japan	IDEOL Kitakyushu Demo	3	2018
Portugal	WindFloat Atlantic	25	2020
Spain	Flocan 5 Canary	25	*2020?*
Spain	Nautilus	5	2020
Sweden	SeaTwirl S2	1	2020
UK	Kincardine	50	2020
UK	Forthwind Project	12	*2020?*
USA (Maine)	Aqua Ventus I	12	*2020?*
France	Golfe du Lyon Pilot Farm	30	2021
France	Groix, Belle-Île Pilot Farm	28.5	2021
France	Provence Grand Large	25.2	2021
France	EolMed (Gruissan) Pilot Farm	30	2021
Japan	Goto City	22	2021
UK	Katanes Floating Energy Par –Array	32	2022
Norway	Hywind Tampen	88	2022
Ireland	Aflowt	6	2022

Remarks: Year of COD reflect developer announcements – inclusion in list does not imply realization. List not necessarily exhaustive.

Sources: Multiconsult/Thema m.fl. (2019), CenSES (2019), Carbon Trust (2018, 2020), WindEurope (2018), Menon (2019)

3.2 Technology, cost and supply chain developments for floating offshore wind

As a dominant floating offshore wind turbine design has not emerged, different initiatives are still validating designs based on different types of substructures in order to find the cheapest, most reliable and easiest to construct solution for wide-scale deployment. These include barge, semi-submersible, spar buoy or tension-leg-platform (TLP) designs.

The process is challenging since all concepts show different strengths depending on seabed conditions, depth of water and harbour as well as the available supply chain. Over time, winning designs will crystallise, and subsequent standardisation and industrialisation of component manufacturing will allow floating technology to exploit large cost reduction potentials.

Due to scaling up of novel manufacturing processes and learnings in the construction process of floating offshore wind turbines, major cost reductions can be achieved on a year-to-year basis. Proven technology also leads to financial risk reduction for investors, increasing the attractiveness of floating wind investments.

However, larger distances to shore also means that the costs for grid connection often increases for floating wind farms. Specialised vessels for operation and maintenance also lead to larger variable costs than the ones incurred by bottom-fixed turbines. However, growth of the sector will likely bring down these costs significantly.

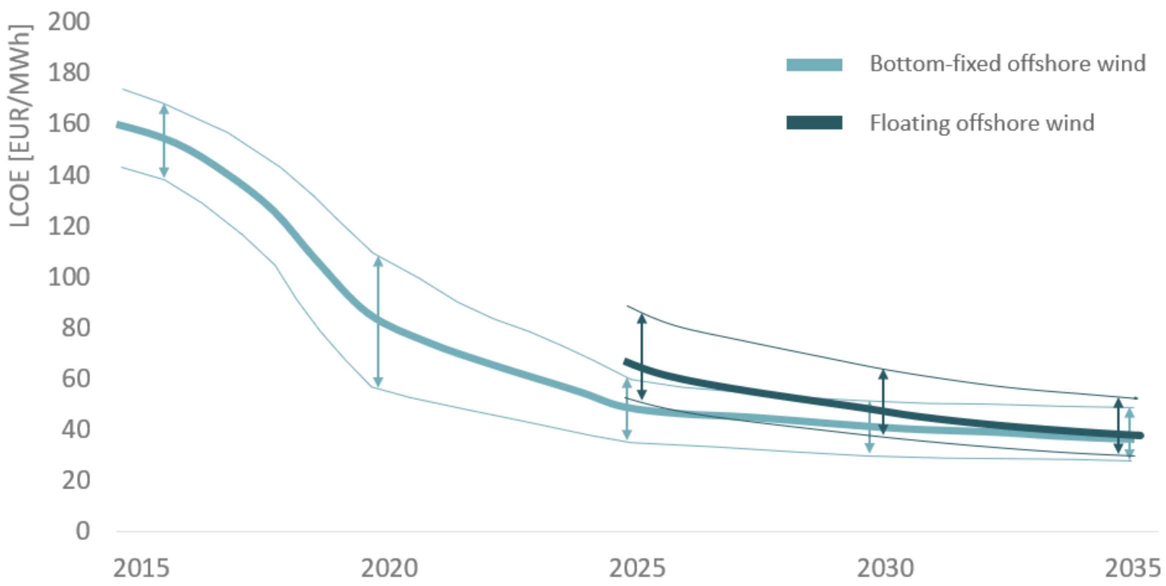
With the industry scaling up, a range of processes related to the deployment of floating wind turbines should be streamlined. With the right infrastructure in place, assembly and pre-commissioning could take place in port, with the assembled turbines then moved to site. The mobility of the floating design could also allow operation & maintenance work to be carried out in facilities at a deep-sea port. Furthermore, steel and other resource use as well as mooring mass decrease for larger turbine designs that are expected to reach 13-15 MW sizes in the middle of the next decade. Innovation in cabling technology, for example related to dynamic cabling systems, should contribute to falling CAPEX costs in the upcoming years.

Several R&D initiatives are addressing areas for which floating designs are likely to incur significant cost reduction. Mooring solutions with synthetic fibre ropes are one example, heavy lift offshore operations from floating vessels is another and monitoring and inspection a third. Further, in addition to just carrying the load of a WTG and avoiding fatigue of the structure, a floater needs to be designed for optimal response to a range of metocean conditions and may also have to adapt to limited water depth at the assembly site. The towing, hook-up and ballasting during installation require another vessel spread than shipment of components on deck of a dedicated vessel, but most likely, cost reduction will also here be achieved through innovations and learning. Currently, no clear market leader exists in floating offshore wind technology. The ramp up in the coming years will decide where the industry sets foot and favourable market conditions will provide the seed for large investments in order to stem the expected capacity expansions.

It is difficult to estimate current LCoE levels for floating projects due to their different sizes and the pre-commercial phase. However, current levels are still expected to lie markedly above 100 EUR/MWh. Increased commercial and research attention is focused on bringing the technology to the market with ambitious targets of achieving a LCoE level of 40-60 EUR/MWh by 2030. DNV GL estimates a LCoE of around 63 USD/MWh by 2030 that could drop to less than 35 USD/MWh by 2050 in its latest energy outlook. The ongoing demonstrator and pre-commercial projects indicate that this level of cost competitiveness could be achieved. However, this has to be demonstrated by deploying commercial, large scale projects to arrive at cost parity with bottom-fixed projects over time, as outlined by BVG Associates in Figure 23. They expect the difference in CAPEX to almost vanish and the still higher O&M costs compared to bottom-fixed projects to be offset by higher capacity factors by 2035.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

Figure 23 LCoE development of floating and fixed offshore wind designs



Source: BVG Associates (2020). Floating offshore wind: roadmap

A decisive role in the expansion of the floating sector could be played by the offshore oil and gas industry. Rather than connecting the farms to the onshore power grid, the electricity generation from the floating turbines could be used to electrify large offshore oil and gas production facilities. That could give floating designs the possibility to scale up while at the same time foregoing a significant percentage of their CAPEX cost, making them cost-competitive with other forms of power generation at an earlier stage.

Bottom-fixed projects will still dominate the market for the upcoming decade. However, targeted government support, as well as a conducive regulatory framework could lead to floating offshore projects being pursued at an earlier point in time, and cost reductions materialising faster. That would enable regions with greater water depths to venture into offshore wind generation and allow for a higher share of wind potentials being used.

Floating offshore wind has similar cost elements as bottom-fixed

The costs of floating wind parks consist of cost components similar to the ones of bottom-fixed offshore wind projects. Turbine costs, substructure costs, offshore substation platforms, O&M costs, capacity factor, project lifetime and WACC also constitute the decisive cost elements in the development of floating offshore wind.

However, floating substructure designs tend to be much more costly and operation and maintenance is more challenging, whereas capacity factors are usually higher due to more steady, stronger winds in the areas chosen for floating projects.

3.3 Future potential of the floating offshore wind sector

Demonstration designs and pilots have led to significant learnings and have proven the viability of larger projects in the future. Risk premiums for floating offshore wind farms are beginning to decrease since higher yields and the operation in rough sea environments could be achieved. Developers are now in the process of realizing larger projects than previously expected, and several countries have set themselves explicit goals for the development of floating offshore wind.

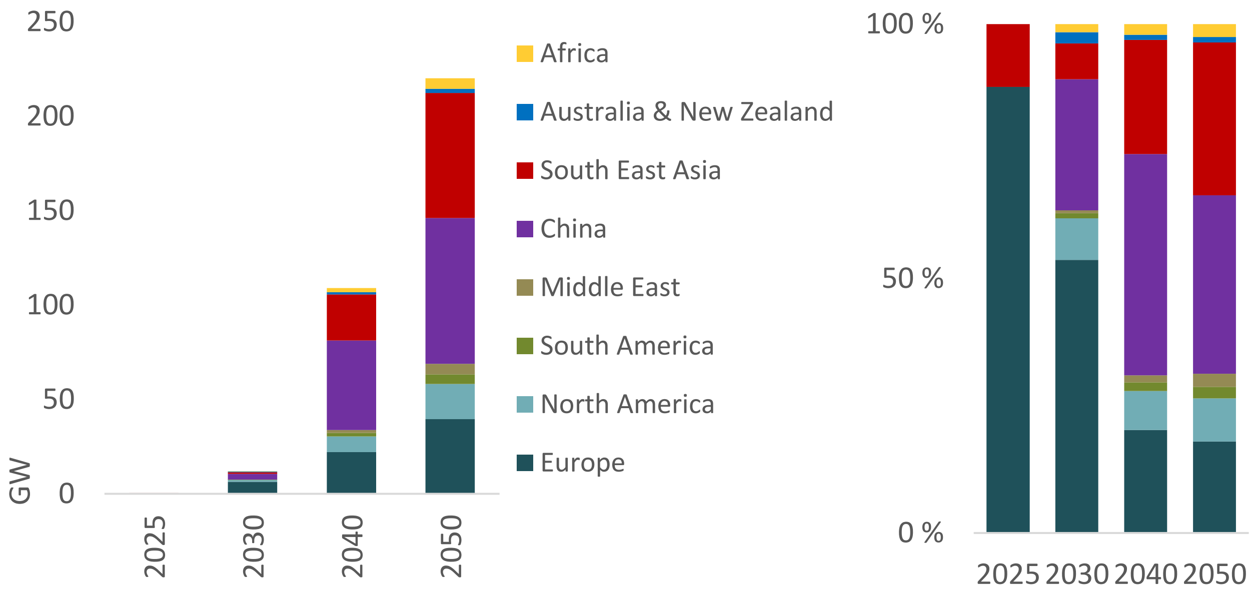
In order to ensure the successful, timely uptake of floating technology, the project pipeline would soon have to form. Considering the technological and regulatory uncertainties (e.g. auction processes) and typical delays and thinning of the projects under development, a significant number of projects would have to see final investment decisions in the short- to medium-term.

A first indicator of that happening are planned projects in Japan and South Korea, where a 1 GW project close to Fukushima and a 1.4 GW floating project close to the city of Ulsan have been proposed. In Europe, France has determined to tender 1 GW per year open to floating or bottom-fixed technology from 2024 onward in its energy transition strategy document that forms part of its NECP. On top of that, 750 MW of floating offshore wind will be allocated in 3 different projects with the first one planned to be awarded in 2021.

As the announced project pipeline shows, the expected date of commissioning for most floating offshore wind projects can be expected in the second half of the decade. According to our forecast, the capacity up until 2025 will thus be practically only located in Europe and Japan, with projects in Asia (mainly China, Japan and South Korea) and the US following shortly with first deployments ahead of 2030. Figure 24 shows that expected floating offshore wind development sees only low capacity levels in the upcoming years, with Europe dominating the emerging sector for the foreseeable future. However, in the 2030s, cumulative capacity will grow from around 12 GW in 2030 to more than 100 GW by 2040 and double again to 220 GW by 2050.

While Europe's market share remains above 50% until 2030, the advent of a Chinese expansion in floating offshore wind as well as significant growth in other Asian countries leads to Europe capturing less than 20 percent of the overall market in 2050. While the North American market, mainly consisting of the US, steadily grows, it remains below 10 percent of the global offshore wind market share with around 19 GW deployed by 2050. Other markets, e.g. Africa, South America, Australia & New Zealand or the Middle East, see cumulative additions that correspond to US levels but remain only small markets, especially compared to Europe, China, South Korea, Japan and other South East Asian countries.

Figure 24 Overall floating offshore wind capacity per region, year (left) and global floating capacity distribution (right)



Source: THEMA calculations

With much of the expansion in the floating sector happening after 2030 and in regions with relatively limited experience with the technology so far, large business opportunities for knowledge transfer and exports could materialise. While this might be true for bottom-fixed offshore wind too, the important difference to the floating sector stems from the fact that no mature supply chains exist that could be reproduced similarly in other regions. Experiences for best practices in the pre-commercial

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

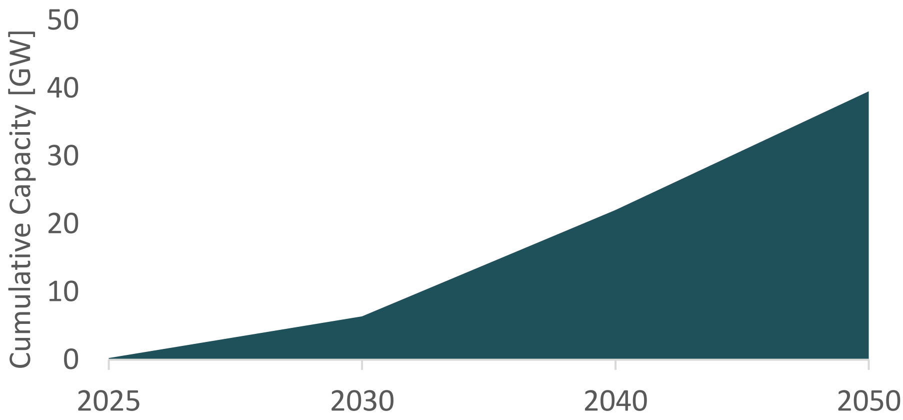
floating offshore wind development phases will likely give large advantages to the early movers in the floating offshore wind.

3.3.1 Europe’s market lead extends into the 2030s, driven by countries with access to the Atlantic, North Sea and Mediterranean coasts

Building on its advantage as a first mover in floating offshore wind technology, Europe will see noteworthy capacity growth earlier than all other regions. Until 2030, more than 6 GW are expected to be deployed according to our model, most of which will be in the UK, France, Portugal, Spain, Norway and Ireland. France is driving investor trust with the first confirmed auctions for 250 MW of floating offshore wind in 2021 and two 250 MW auctions in 2022 with target prices of 120 EUR/MWh and 110 EUR/MWh respectively.

In the 2030s, however, market growth in the floating offshore industry will kick off in earnest. Figure 25 shows a capacity increase from 6 GW in 2030 to 22 GW by 2040 and almost 40 GW by 2050. As the best locations in shallow waters near the coasts are starting to be exploited by bottom-fixed installations, the option to build floating wind farms in deep waters close to industrial demand will become competitive, e.g. due to drastically lower connection costs.

Figure 25 Floating offshore wind capacity in Europe through 2050

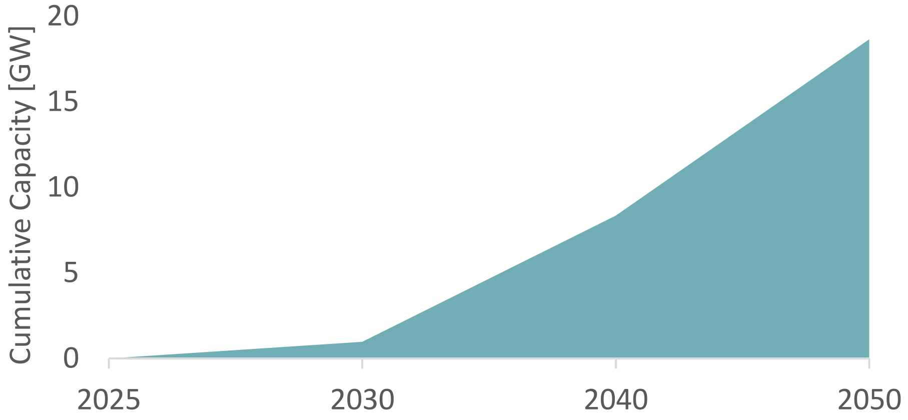


3.3.2 North America will rely on floating designs in California and parts of its East Coast

Due to California’s ocean bed generally descending too fast to support monopile or multi-leg jacket structures at larger scale, floating offshore wind remains the only solution for the state. A non-legal target of building 10 GW of that technology by 2040 is currently being discussed. Maine is also discussing the build-out of floating capacity owing to its coastal waters being unsuitable for bottom-fixed designs. Principle Power is in the early stages of planning a 150 MW project off the West Coast of the US which is still described as a pre-commercial project.

Still, the market is not expected to see commercial projects in the near future. Due to the abundant land, the cost competitiveness of other technologies and a rather stifled development of the offshore wind sector in general, we expect only a little more than 8 GW of floating turbines being built by 2040, up from 1 GW in 2030. By mid-century, the cumulative capacity will be slightly short of 19 GW, as depicted in Figure 26.

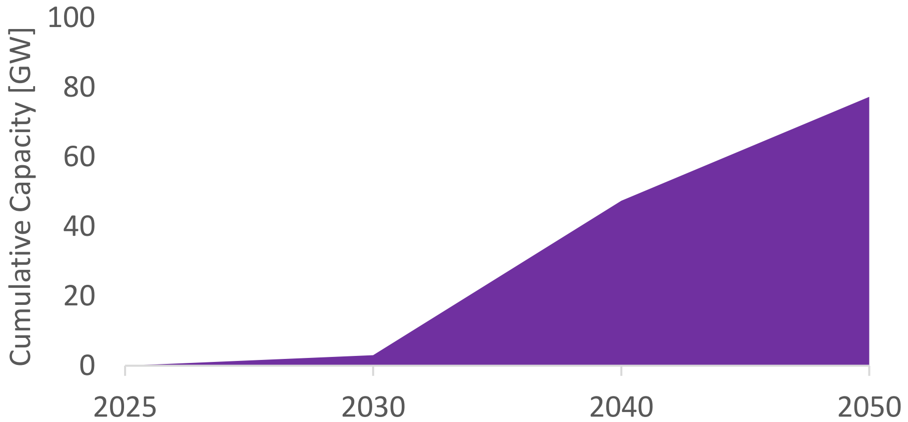
Figure 26 Floating offshore wind capacity in North America through 2050



3.3.3 China becomes market leader in the 2030s due to its scaling advantages

Just as is the case in bottom-fixed offshore wind, China will profit from its sheer scaling advantage in the floating offshore wind sector too. While not seeing major capacity additions until 2030, we expect the sector to take off in the period to 2040 with almost 50 GW of cumulative capacity by 2040 and close to 80 GW being commissioned by 2050, as can be read off of Figure 27.

Figure 27 Floating offshore wind capacity in China through 2050



China possesses a large area of rather shallow waters between the mainland and the South China Sea that is well suited for the expansion of fixed designs. That is the reason for a comparatively lower share of floating wind compared with most other regions arriving at about 20% of the overall offshore wind market in the country by 2050. Still, it would represent the largest deployment in any region.

3.3.4 South East Asia sees strong growth after 2030 driven by Japan and South Korea

With Japan and Korea driving the expansion of floating offshore wind, South East Asia will see a quick growth of the sector after 2030 when maturity of the technology is reached. Mainly relying on pilot projects at the moment, the two countries are working eagerly on bringing down the costs for floating designs since their resource availability onshore is limited by their large population density and rather mediocre conditions for the expansion of bottom-fixed offshore wind due to the steeply descending seabed in their coastal waters.

South Korea pursues floating demonstrator projects and heavily pushes for innovation to secure access to the country’s more promising wind resources in locations not suited for bottom-fixed

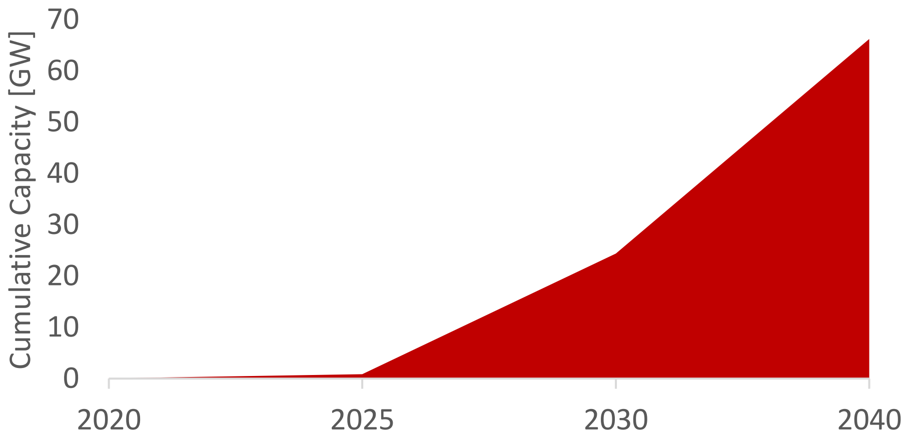
THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

offshore wind turbines. Japan is also a first mover that develops the floating sector by giving market access to both, large domestic and international players.

While these two countries spearhead the sector together with Europe, other countries in the region do not feel such a strong urge to invest in floating capacity owing to shallower water and better resource potentials for other technologies.

According to our forecasts, South East Asia will see a rapid expansion of floating capacity after 2030, reaching almost 25 GW by 2040 and thus overtaking Europe in capacity build-out. It is also the region with the strongest growth in the decade leading up to mid-century with more than 40 GW of additions in 10 years, bringing overall floating capacity up to more than 66 GW. Figure 28 shows these developments.

Figure 28 Floating offshore wind capacity in South East Asia through 2050



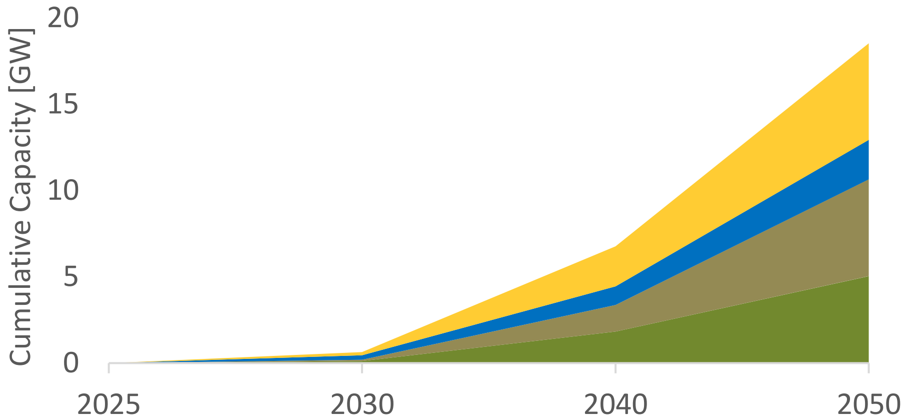
3.3.5 South America, the Middle East, Africa and Australia and New Zealand remain comparatively small markets with a delayed development of floating offshore wind

In a similar vein to bottom-fixed offshore wind deployment in these regions, difficult financing conditions due to political and regulatory uncertainty play a role in the development of floating offshore wind in South America, the Middle East and Africa. With only small demonstration designs coming online before 2030, the sector grows modestly in the subsequent decade to arrive at ca. 3 GW in each region by 2040. In 2050, South America sees 5 GW of floating offshore wind being commissioned while the Middle East and Africa each expand to close to 6 GW, as can be seen in Figure 29.

Australia and New Zealand on the other hand have ample resources for bottom-fixed offshore wind as well as other resources that make the development of floating designs difficult before market parity is potentially reached sometime between 2030 and 2040. Moreover, the region has the lowest population and thus the smallest electricity demand, which is why volumes seem comparatively meagre. With a third of overall offshore generation coming from floating wind farms and almost 4% of total power demand being covered by the sector in 2050, the sector is quite important in relative terms.

With our assumptions, we expect a sum of close to 20 GW of floating offshore generation to be deployed by 2050 in these regions in total (cf. Figure 29), which leads to floating wind farms providing around a third of total offshore wind generation.

Figure 29 Floating offshore wind capacity development in Africa, Australia & New Zealand, the Middle East and South America through 2050

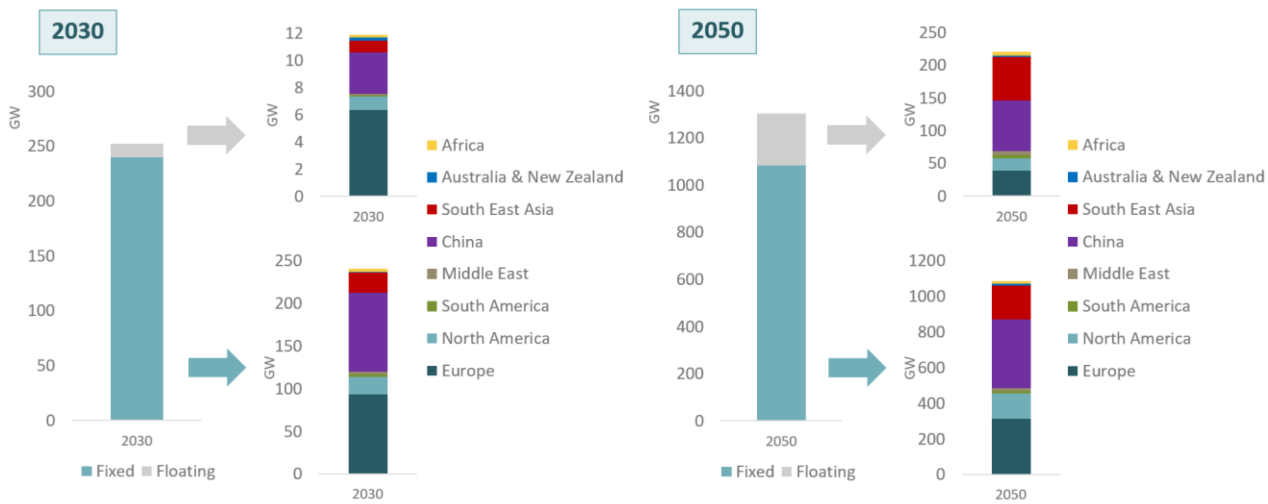


3.4 Comparison of the developments in floating and bottom-fixed offshore wind

While the offshore wind sector is expected to grow immensely in the upcoming decades, the size difference of the markets for bottom-fixed offshore wind and its floating counterpart is expected to remain significant. In 2030, more than 95% of the installed offshore wind capacity is expected to consist of bottom-fixed designs, and their share decreases to slightly over 80% by 2050.

As shown in Figure 30, offshore wind capacity increases fivefold between 2030 and 2050. Most of the growth of floating offshore wind takes place after 2030, with market size soaring to multiply twentyfold. Although bottom-fixed technology remains dominant and reaches 240 GW in 2030 and almost 1100 GW in 2050, the market size of floating turbines still reaches grows from a little over 10 GW in 2030 to around 220 GW globally in 2050 and thus involves viable business opportunities.

Figure 30 Comparison of bottom-fixed and floating offshore wind expansion in 2030 and 2050, per technology and per region



The European market will remain dominant for both foundation types in the medium term, however Asian countries are expected to become the main growth areas towards 2050, with China leading both, bottom-fixed and floating, markets. What could come as a surprise, however, is that Europe's relative share of capacity build-out for floating designs will be smaller than for the bottom-fixed sector. Countries such as South Korea and Japan will rely heavily on floating technology to achieve their climate objectives and will thus invest more into expanding their generation through floating wind farms. The same is true for the world's fifth largest economy, California, that pursues ambitious decarbonisation targets but has a coastline that is generally not suitable for the construction of bottom-fixed offshore wind.

According to the IEA, about 40 percent of the full lifetime costs in offshore wind have synergies with the value chain in oil and gas. The share is largest for floating installations due to their reliance on substructures and subsea construction which represent comparatively larger cost components than for bottom-fixed assets. Large overlaps also exist in the planning and best practice utilisation of vessels for installation as well as operations and maintenance of the platforms. The positive outlook for offshore wind growth thus entails large opportunities for companies in the Norwegian offshore industry supply chain.

The next chapters will look into the different segments of the value chain and exhibit where Norwegian players are already active and where the most potential for future exports and value creation can be found when taking into account the existing know-how of the Norwegian shipping and offshore oil and gas industries.

4 SEGMENTATION OF THE VALUE CHAIN

The offshore wind industry is now specialized with factories for production of offshore turbines separated from the starting point in onshore wind. Bespoke vessels have been developed for installation, operation and maintenance - consultants, lawyers and finance institutions have set up their special divisions for offshore wind. Countries around the North Sea have the most developed value chain and several actors are now expanding into new markets in South East Asia, adapting their serviced to local requirements.

For floating wind, the structures of the industry are still under development with newcomers from oil and gas entering several markets. Except for the turbine supply, it is likely that the floating wind industry will establish a value chain different from what we have seen for fixed turbines as the vessels, substructures, cable arrangement and O&M will require other solutions.

In the following, the various typical elements of an offshore wind farm are described. An analysis of the potential for the Norwegian supply chain within each of these market segments is given in Appendix I - Methodology: Assessment of Norwegian market shares in global offshore wind.

The following overview contains segments which are generic for offshore wind (both valid for bottom-fixed and floating) and those specific for floating. Market segments which are specific for floating offshore wind have been highlighted in separate focus boxes.

4.1 Description of the different segments

Devex

This segment covers all the early phase development and consenting work, e.g. the environmental and societal impact assessment, offshore surveys, resource assessment, planning and cost calculations.

Turbine Supply

Wind turbine supply is often regulated in a contract called Turbine Supply Agreement (TSA) between the Original Equipment Manufacturer (OEM) and the customer. The technical scope is usually a complete turbine from the bottom tower flange and up, including the blades. In addition, a Maintenance and Service Agreement (MSA) can be a part of the contractual scope, where the OEM is responsible for the turbine performance during (typical) the first 2-5 years. Transportation from the turbine factory to an agreed staging port is usually part of the turbine supply.

Turbine Installation

A wind turbine installation vessel is collecting typically 3-5 sets of turbines at the staging port and bring these to the project site. The most common way of installing turbines on fixed foundation is to use dedicated jack-up Turbine Installation Vessels (TIV). The turbine installation contractor is hired by the turbine supplier on EPCI contracts and the assembly is performed by operators from both companies.

Turbine installation on floating foundations has so far only been done on demonstration and pilot projects in benign waters or in port, either by very large and stable floating crane vessels or by crawling cranes at the quay.

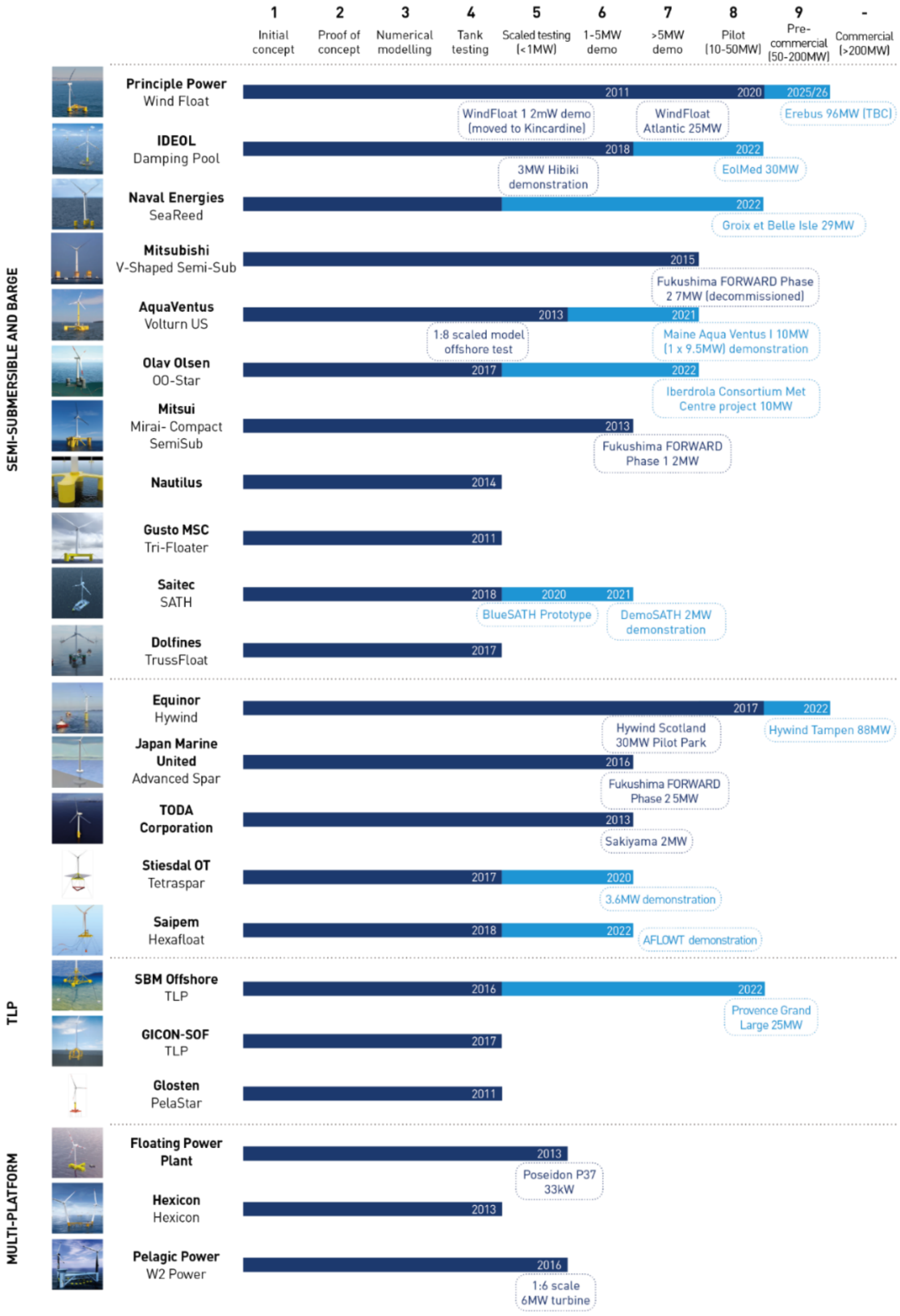
Foundation supply

This segment includes complete delivery of the foundations (fixed or floating) shipped to an agreed staging port.

For floating wind foundations, three different types have advanced to become more bankable than others. This is the three-legged semi-submersible, the damping pool barge and the spar buoy. Figure 31 shows the Technology Readiness Level (TRL) achievements of individual foundation designs.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

Figure 31 Technology Readiness Levels of floating offshore wind designs



Source: Carbon Trust (2020). Floating Wind Joint Industry Project.

For bottom-fixed turbines, there are today mainly three types of structures, with some variations.

1. The monopile, which is the dominating option in most markets, has become very mature but require considerable investment in production facilities. A somewhat similar cylindrical variant with suction bucket is an option (e.g. developed by Universal Foundation AS, owned by Fred Olsen).
2. The jacket foundation (on piles or suction buckets), has similarities with the even larger oil and gas structures for which more fabrication sites exist.

3. Gravity base structures (GBS), usually made of reinforced concrete. Comes in lifted or float-out-and-sink versions. The GBS offer possibilities for local production and for some projects this can give priority.

Just like the bottom-fixed structures, floating concepts are made of both steel and concrete, with advantages/disadvantages regarding local content. Concrete structures offer the ability to support local industry in the country where the wind farm is located making these foundations less competitive for export to foreign markets. Steel structure fabrication require some permanent yard facilities that not all domestic markets can offer. The foundation supplier can either be part of an EPC(I) contract agreement or deliver its product directly to the developer in a multi-contract structure.

Floating Moorings Supply

The floating mooring supply include the anchors, the mooring lines, the fairleads and winches connected to the main structure. Anchors comes in several designs and are often similar to what is used for oil and gas platform mooring.

Fixed Foundation Installation

This segment includes complete installation of the fixed foundations.

Monopiles have typically been installed by large jack-up vessels which provide a stable platform for lifting and handling of the heavy piles, but heavy-lift floating crane vessels using several anchors are also used. At sites with suitable soil conditions (sand), monopiles might be forced partly into the seabed by vibration hammers, which emits less harmful noise into the water than hydraulic hammers. The recent development of advanced pile grippers has made it possible to also install monopiles from dynamically positioned floating vessels.

Jacket foundations for offshore wind turbines are usually installed on pre-piled piles or come with integrated suction buckets. When pre-piling, a lighter vessel uses a template to locate three or four piles in an accurate position and the jacket legs are placed inside these piles and grouted during installation. In hard soil conditions, use of drilling machines might be necessary to achieve required penetration.

GBS foundations can either be lifted and transported on heavy lift vessels or towed to site utilizing its own buoyancy. The seabed will usually need some preparation before set-down of the GBS.

The installation work can be part of a multi-contract strategy or an EPCI contract.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

Floating Marine Operations

This segment includes complete installation of mooring systems and the installation of floating turbines at site. Inshore assembly of turbines on top of floating structures is covered by the same segment regardless of crane type.

The mooring solution can be installed before the floating turbine is transported to site and to a large extent, the oil and gas industry experience and solutions can be used, utilizing a large fleet of anchor-handling vessels.

The operation of assembling the main turbine components in port and hook-up of the floating turbine at site is still very immature, and it is likely that this becomes more standardized as the floating structure market gets more competitive and technically consolidated. Floaters with moderate draft, as semi submersibles or barge-type structures are usually equipped with turbines at quay side using large crawler cranes. It is likely that also smaller jack-up vessels can take a portion of the market for turbine assembly in port. Deep draft spar buoys, like the Hywind design, can use large floating crane vessels to install turbines in benign waters, or onshore cranes where the port facilities are deep enough to locate the substructure within the reach of the crane.

The Floating Wind Joint Industry Project organised by Carbon Trust (2019) identified that it might be advantageous to perform more of the marine operations in-situ rather than in port:

> *"The Floating Wind JIP's Phase I Infrastructure and logistics study identified that, for several floating wind concepts, port-side operations are unlikely to be feasible due to draft and/or towing constraints. Even for concepts advocating port-side maintenance operations, there are challenges regarding the economic and technical viability of such an approach. In a large-scale floating wind farm, it is possible that undertaking more operations in-situ at the offshore site could be advantageous, and in some cases will be essential".*

Array Cables

This segment includes complete delivery and installation of the array cables.

Array cables are connecting several turbines together and with the offshore substation. The array cable supply and installation may be delivered under one contract or the installation work can be performed by a separate marine contractor. This segment includes delivery of all cable components and connectors, trenching work, cable protection, and installation.

Export Cables

This segment includes complete delivery of and installation of the export cables, HVAC or HVDC.

HVAC export cables are used for wind farms with short to medium distance to shore and HVDC cables for distances more than 80-100 km. HVDC systems are more expensive but utilize the full capacity of the cable as there is no reactive power typically restricting the capacity of long distance AC cables. Supply of export cables is dominated by a few international well-established actors, some having their own installation vessels.

Dynamic cables for floating applications

For floating structures, dynamic cables will be required. This is an area where Norwegian suppliers have track record from the O&G industry and is considered a high opportunity.

OSS/OnSS Electrical & Civil

This segment includes complete substation delivery including installation at site for the OSS and OnSS, as well as electrical and Civil works on land (AC and DC).

Offshore substations are increasing the voltage before sending the electricity into the export cable, and the receiving onshore substation is reducing the voltage to align it with the onshore grid. The rationale for higher voltage is that it requires less cross-section area of the cable and hence saves cost. HVDC substations convert the electricity from AC to DC before exporting to shore and back to AC on land to fit with the onshore grid. Substations also have equipment to manage and optimize the power flow in the cables.

OSS Foundation

This segment includes complete delivery and installation of the substation foundation. Bottom fixed offshore substation platforms are installed on monopiles, jacket structures or gravity-based structures.

Floating offshore substations

So far, no floating substations have been realised for offshore wind farms. Norwegian suppliers have knowledge and track record within floating structures from the O&G sector which presents a great opportunity for application within the floating offshore wind sector.

Other Capex

This segment includes management cost, contingency and insurance capex.

Opex

This segment includes the operational cost of the generation assets, export cable OPEX, offshore and onshore substation OPEX and operating insurance.

Abex

This segment includes all activity and cost related to decommissioning and abandonment of the assets.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

5 MARKET POTENTIAL FOR NORWEGIAN PLAYERS IN OFFSHORE WIND

While many countries are trying to position themselves as frontrunners in the nascent offshore wind industry, the decades-long experience from activities in the offshore oil and gas sector gives Norway's industry a head start in specific value chain segments. Based on existing knowledge, the review of recent literature and the development prospects of offshore wind globally, an in-depth assessment of the potential of Norwegian players to capture market share along the bottom-fixed and floating offshore wind value chain is conducted.

5.1 Norwegian industry market potential assessment

Uncertainty in the development of the Norwegian market share in different segments of the offshore wind industry is substantial, and thus there is a wide range of outcomes for the estimated potential turnover.

We have therefore developed three scenarios for the turnover that could be captured by Norwegian industry players in the global offshore wind market through 2050: A Medium Base Case scenario, a High Accelerated Growth scenario and Low Slow Progression scenario.

These three scenarios have been developed to capture the inherent uncertainty (Low, Medium, High) on long-term value for the Norwegian industry under the three scenarios (Slow Progression, Base Case, Accelerated Growth). The Medium Base Case should be interpreted as our assessment of best guess market development. Our High Accelerated Growth scenario provides an upside to this, both in terms of using the top of the expectation range and under the circumstances described in the growth scenario. Our Low Slow Progression scenario contains a development path for the Norwegian industry that could be achieved with a high degree of certainty as it uses the lower range for each segment and assumes a development less favorable than our best guess.

The basis are the market developments in the various regions presented in *Chapter 2* and *Chapter 3*. Market development is converted to investment profiles per regional market and disaggregated into cost segments as presented in *Chapter 4*. The Norwegian market share is described in *Appendix I - Methodology: Assessment of Norwegian market shares in global offshore wind*.

5.1.1 General/overall results

In our Medium Base Case, floating and bottom-fixed offshore wind combined, we estimate total turnover for Norwegian players to represent 2.1 bn. EUR/year in the near term to 2025, increasing to 7.2 bn. EUR/year toward the end of the 2040s.

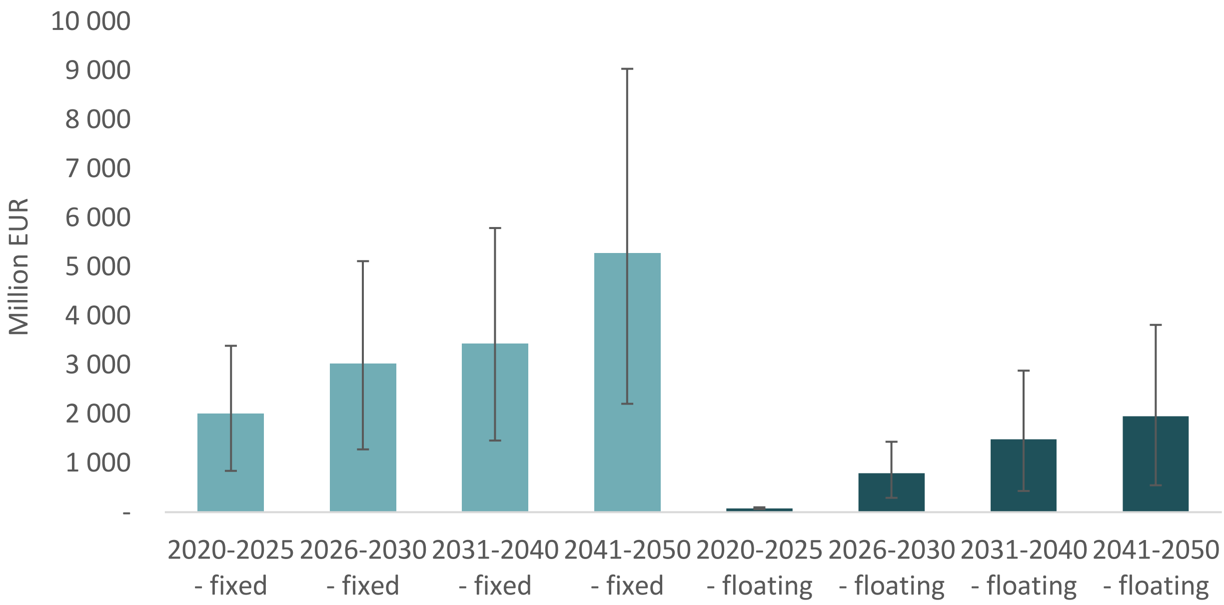
The distribution of bottom-fixed versus floating in expected offshore wind capacity build-out is reflected in the results of the analysis. Specifically, bottom-fixed offshore wind will remain the key source of turnover for Norwegian players, accounting for on average EUR 3 bn. in the 5-year period from 2026 to 2030 and EUR 5.3 bn. in the 2040s. Similarly, floating offshore wind makes up a mean of slightly below 800 MEUR/year in the 2026-2030 period and doubles to an average of almost 2 bn. EUR in decade leading up to 2050

There is significant uncertainty on both build volumes and the capacity at which Norwegian players can capture markets shares in the different cost segments. This is reflected by substantial span in expected Norwegian turnover in the High and Low Slow Progression outcomes.

Specifically, in the High Accelerated Growth scenario, we believe Norwegian players could capture up to 12.9 bn. EUR/year by at the end of the forecast period, 9 bn. EUR/year of which to bottom-fixed developments. On the other hand, in the Low Slow Progression scenario, we estimate Norwegian turnover is limited to 2.8 bn. EUR/year in the same period.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

Figure 32 - Average yearly Norwegian turnover for each period in the three scenarios



5.1.2 Medium Base case by region

We expect the European market to remain the largest market for Norwegian players both for bottom-fixed and floating offshore wind. This region makes up for a mean turnover of 2.7 bn. EUR/year around 2030 and 3.7 bn. EUR/year in the 2040s or 72% and 51% of global opportunities for Norwegian players, according to our estimates. Large-scale build-out of offshore wind capacity, political ambition, and close operational and cultural proximity explain this importance of Europe to Norwegian players.

Figure 33 Norwegian turnover for bottom-fixed and floating offshore wind per year in different time periods and geographies in the Medium Base case

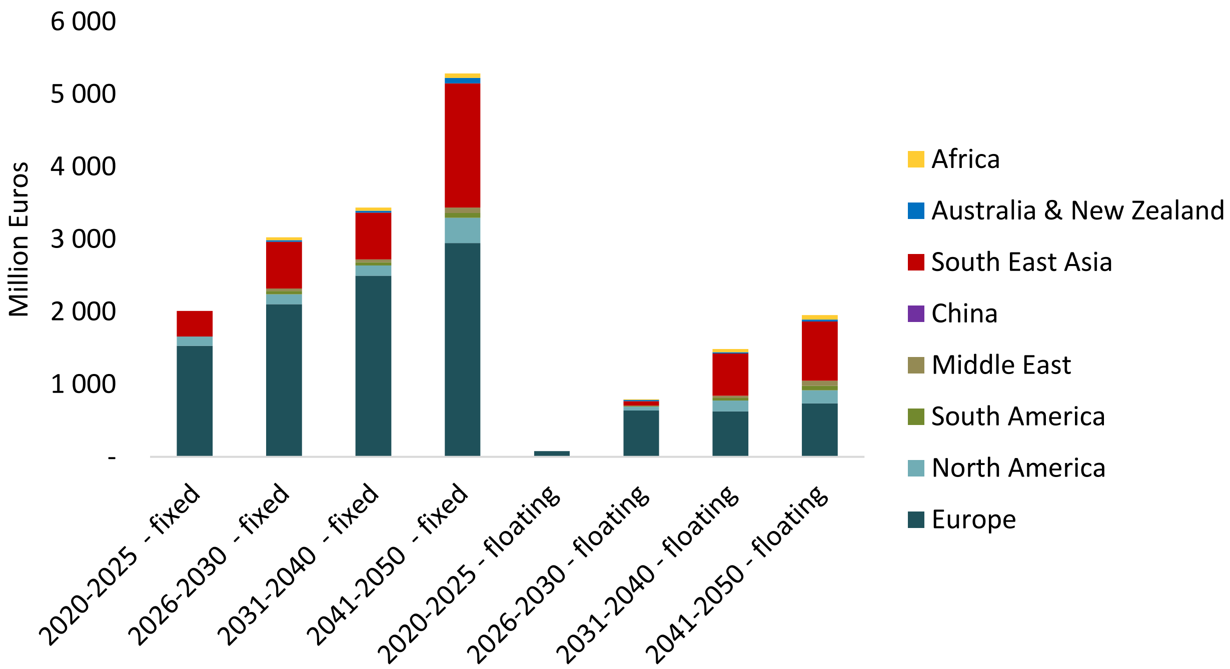


Figure 33 above shows that South East Asia and North America follow in second and third place in terms of opportunities for Norwegian players in the global offshore wind market. These two regions

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

represent a yearly average of 2.5 bn. EUR and 530 MEUR in the decade before 2050, making up 35% and 7%, respectively, of global estimated Norwegian turnover.

We believe only smaller pockets of opportunity exist for Norwegian players in remaining regions as these together make up less than 498 MEUR annually in the period leading up to 2050 for floating and bottom-fixed offshore wind combined which is close to only 7% of estimated overall potential.

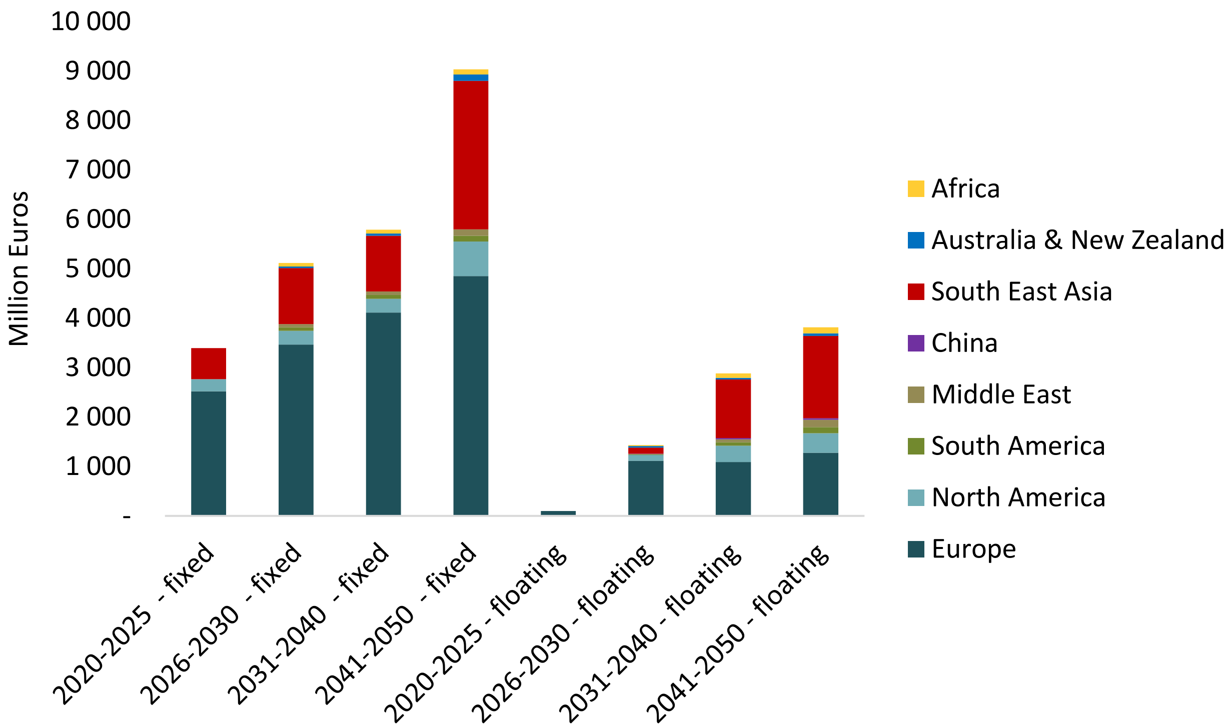
5.1.3 Accelerated Growth case by region

The relative predominance of the European market remains also in the Accelerated Growth case, as this region represents a turnover of more than 6.1 bn. EUR/year towards 2050. That means that close to 48% of the total market share for the Norwegian supply chain is in Europe.

As shown in Figure 34, opportunities in bottom-fixed offshore wind amount to 3.7 bn. EUR/year over the next five years. This sum rises to an average 9 bn. EUR/year in the ten years before mid-century.

While floating offshore wind again does not play a role in the near term, more than 3.8 bn. EUR/year are expected to be harnessed by Norwegian floating offshore wind operations globally in the 2040s (cf. Figure 34).

Figure 34 Norwegian turnover for bottom-fixed and floating offshore wind per year in different time periods and geographies in the High Accelerated Growth scenario



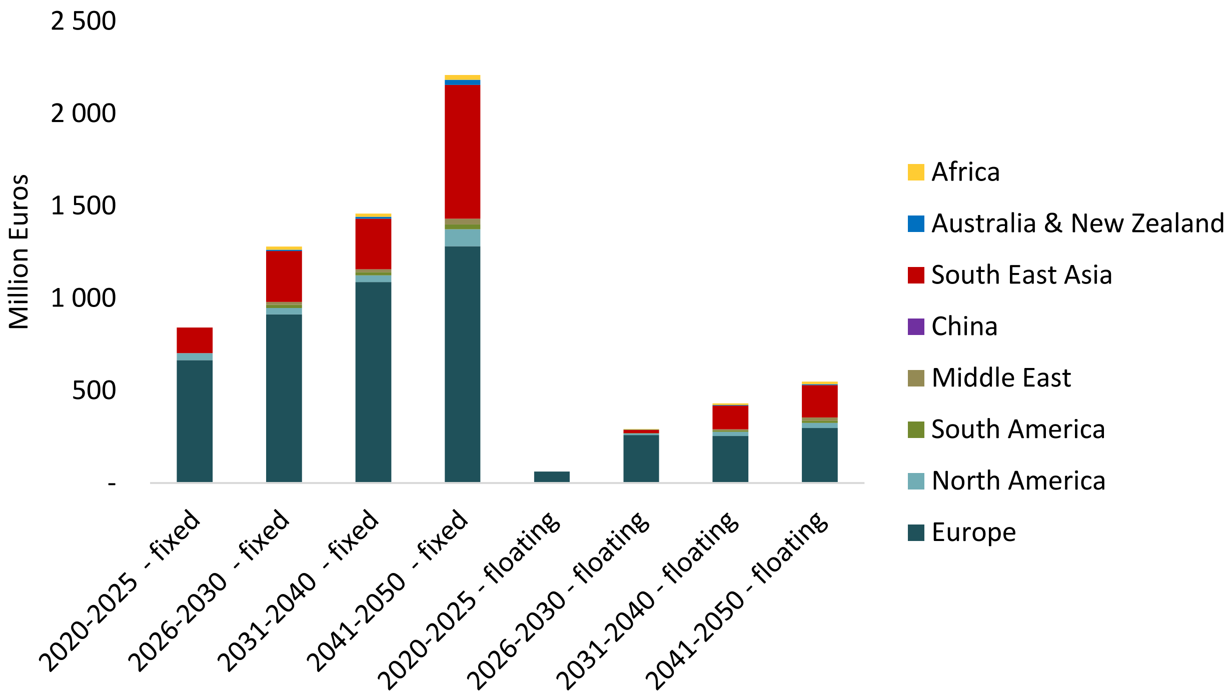
5.1.4 Low Slow Progression case by region

Bottom-fixed turnover in the Slow Progression scenarios can be seen in Figure 35 and sums up to a mere average of 903 MEUR/year in the period up to 2025.

As most deals are inked in Europe and some in South East Asia, while all other regions have a smaller involvement from Norwegian industry, the average annual amount rises to 2.8 bn. EUR in the last decade in the period under consideration.

Figure 35 also includes the Low Slow Progression scenarios revenue-creating opportunities in floating offshore wind that are estimated to increase and reach a total of 292m EUR/year on average from 2026 onwards until 2030. In the 2040s, the revenue potential rises to 549m EUR per year on average.

Figure 35 Norwegian turnover for bottom-fixed and floating offshore wind per year in different time periods and geographies in the Low Slow Progression case



5.2 An introduction to Norwegian participation in offshore wind

Norway remains a niche offshore wind market compared to European counterparts. Nevertheless, a lack of home-market has so far not deterred Norwegian players from establishing key positions in select segments in the international market.

Notable examples of this to date include:

- In **project development**, through a range of project acquisitions and partnerships, Equinor is a leading global offshore wind project developer with presence in key markets including Germany, UK and the US, with developments in more countries on the horizon.

  The firm is spearheading the deployment of floating offshore wind technology as its Hywind technology remains the most deployed floating offshore wind technology worldwide.

- In **equipment manufacturing**, French-owned Nexans boasts substantial production capacity in Norway and is a well-established supplier of export, inter-array, and onshore cables for offshore wind developments.

  Other notable Norwegian equipment manufacturer serving offshore wind include Aibel and Kværner in the substation platforms and substructure segments.

- In the diverse **Engineering, Procurement, Construction, and Installation (EPCI)** segment, a range of Norwegian players with roots in oil & gas and maritime industries has established key positions.

  These include Fred. Olsen Windcarrier, specializing in wind turbine installation, and players such as Solstad and Offshore Heavy Transport (OHT), both recently announcing sizable contracts for services in the international market.

As such the Base Case already take account for an already positive market development within the Norwegian offshore wind supply chain. However, a range of drivers and inhibitors shape the offshore wind market environment within which the Norwegian supply chain are seeking to secure market

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

shares in the future. The development of such drivers or inhibitors are reflected in the Accelerated Growth og Slow Progression scenario.

We seek to discuss a selection of these in the paragraphs below. First as pertinent to offshore wind in general, followed by remarks specific to Norwegian market shares in floating offshore. How these drivers develop will determine which scenario will materialise for Norwegian market shares and turnover in the offshore wind market.

5.3 Key drivers/challenges for Norwegian market shares in in offshore wind

5.3.1 Norwegian players currently face an appealing "window of opportunity" in offshore wind

Simultaneously, players in incumbent industries are looking for growth in new markets. This is particularly true for O&G players struggling to reconcile long-term uncertainty on conventional exploration activity and the economic transition into more carbon-efficient and sustainable business models.

Political ambition in Norway to leverage synergies and create new growth in renewable energy is prominent.

These coinciding drivers together create an appealing opportunity in offshore wind for Norwegian firms spanning a vast range of sectors and value chain segments.

5.3.2 Project development by Norwegian developers could facilitate access to the global market for Norwegian supply-chain players

First contracts are crucial for a foothold in offshore wind. But Norwegian suppliers wishing to position in the market may struggle to obtain important first deals due to the current lack of a home market.

Although not a condition for foothold, existing supply relations with Norwegian developers of offshore wind projects globally may facilitate access to the market for these players.

Equinor remains the most prominent Norwegian offshore wind developer with ownership of a pipeline of more than 12 GW of projects worldwide.

Projects developed by lower-tier Norwegian developers such as Fred. Olsen Renewables and Aker's development arm Aker Offshore Wind remain mostly in early stages of development but could become instrumental for Norwegian sub-suppliers depending on how these mature going forward. In addition, there are several Norwegian companies going into project developments that have still not announced their ambitions.

5.3.3 Cost, competition, and innovation are key challenges to strong Norwegian presence

Previous efforts to capture, maintain and expand market shares in offshore wind roughly reflect historical capacity build-out patterns. Thus, leading current suppliers of products and services to offshore wind are largely concentrated to countries in North-western Europe and China, with only select exceptions in the more nascent North American market.

Given the expected growth of the market in the next decades, Norway and other similarly industrialized economies are positioning for growth in offshore wind. The success of Norwegian firms in this increasingly global market will hinge on some key factors, including:

- **Cost:** To which extent can Norwegian firms provide value in a cost-competitive way?
- **Competition:** In which ways can Norwegian firms leverage experience from other industries – and which are core competitive advantages of Norwegian firms?

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

- **R&D**: Targeted research, development and innovation efforts can provide competitive advantages that add momentum to Norwegian products in global offshore wind, especially in early scaling phases.

A range of other factors make up the dynamic market environment for offshore wind within which Norwegian firms are targeting growth – some of these are discussed in the following paragraphs.

5.3.4 Emergence of isolated supply chains could represent barriers for growth outside Europe

Leading offshore wind project developers and key supply chain players are seeking presence across regional markets in an increasingly globalised market for offshore wind.

But isolated supply chains for offshore wind already exist to a full extent in China which, despite its role as key global market for new annual additions, remains largely off-limits to overseas players looking for a position.

Drivers behind such supply chain isolation are manifold and include factors such as geographical, cultural and operational proximity, cost, standards on quality/health/safety, and protectionism, whether explicit or not. Other similar regional supply chains could develop as the market for offshore wind continues to mature and increase in size.

Global offshore wind players need to navigate this type of regionalization to defend market shares, should they emerge.

5.3.5 Development of a home-market likely to accelerate strategies of Norwegian offshore wind players in the international market

For Norway to position itself as an international supplier of offshore wind technology, it is valuable to establish a home arena in which supplier can commercialize technology, expand competence and reduce costs.

Comparative advantages in topology, competence and innovation ability in marine and offshore industries make Norway particularly promising for floating offshore wind technology for which national hubs are yet to be fully established.

5.4 Special remarks on drivers/challenges for Norwegian market shares in floating offshore wind

5.4.1 Competing technologies are currently challenging Norway’s floating offshore wind leadership

Equinor has championed floating offshore wind technology through its Hywind technology, most recently through the commissioning of a 30 MW project off Scotland in 2017 which remains the largest fully commissioned floating offshore wind project to date.

US firm Principle Power and French firm Ideol have also successfully showcased proprietary solutions for floating offshore wind technology in Europe to date.

But tables are turning for lead in this still nascent segment of offshore wind technology. In fact, other concepts for floating foundations are being showcased in at least 10 projects expected to reach commissioning in the next 2-3 years according to developers’ announcements. In particular, the 50 MW Kincardine floating offshore wind farm off Scotland is set to becoming the largest fully commissioned floating offshore wind farm when commissioned at the end of 2020.

Aker owns a minority stake in this project’s floater technology supplier Principle Power. But this string of new floating offshore wind capacity in the region highlights not only the rapid growth of the market but also the heterogeneity of proposed solutions.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

5.4.2 Recent announcements show Norwegian players seek supply positions in strategic floating offshore wind technology initiatives/alliances

The floating offshore wind market is characterized by heterogeneity in proposed solutions and a tightening race to develop these into commercially viable products.

In this market environment, diversification is key to secure Norwegian market shares in the longer term and hedge against this incumbent uncertainty on winning designs.

Such diversification is already taking place among Norwegian firms targeting opportunities in floating offshore wind. Specifically, Norwegian firms are either actively developing new concepts for floating offshore wind or forging supply relationships or alliances with firms that do.

Several recent examples highlight this trend:

- In March 2020, Offshore Wind Consultants, a subsidiary of Norwegian firm AqualisBraemer, entered a contract for engineering services to Simply Blue Energy and Total's Erebus floating wind project located off the coast of Wales, UK.
- In November 2019, cable supplier UNITECH Offshore announced a deal for the supply of dynamic cables to the Tetraspar demonstrator project developed by players including Shell and Innogy.
- Substantial Norwegian content in the 88 MW Hywind Tampen project should see milestone contracts in floating offshore wind for Norwegian entrants. These include Seasystems and WoodGroup, announcing deals with project sponsor Equinor for mooring systems and modification works in April 2020 and late 2019, respectively.
- Aker Solutions holds 18.8% in US technology firm Principle Power which owns one of the most proven floating offshore wind concepts to date. The promise of this technology was highlighted by intentions to develop a 500 MW floating offshore wind farm off South Korea announced in October 2019.

5.4.3 Norwegian suppliers increasingly position in floating offshore wind niches

After adoption of main design principles, potential for incremental CAPEX and LCoE reductions remain abound for floating offshore wind due to the relative immaturity of the technology.

A range of Norwegian firms are positioning themselves to serve developers of floating wind products and services that can unlock some of these.

Some examples include:

- The ShallowFloat initiative in the US backed by players including Principle Power and its Norwegian minority owner Aker.

  This and other efforts to accommodate floating offshore wind in water depths below the current 50 to 60 meter threshold for bottom-fixed structures could substantially increase the market potential for floating offshore wind solutions worldwide, also in markets where bottom-fixed solutions currently dominate.
- Floating structures require specialized mooring and cabling systems due to factors such as movement and underwater currents.

  Norwegian suppliers such as UNITECH Offshore, Nexans and Aker Solutions are positioning themselves as key suppliers of such dynamic cables, drawing on experience from historical deliveries in O&G.
- Differing access points and movement patterns require special considerations for access and transfer of equipment and personnel to/from floating offshore wind installations, not least in operational phases of these projects.

Several Norwegian firms deliver access solutions addressing these particularities of floating structures, such as UpTime which can leverage substantial experience from O&G and bottom-fixed offshore wind into floating wind.

5.4.4 Specialized Norwegian experience from O&G, marine industries could be mobilized to tackle inherent floating offshore wind challenges also in installation, operations, and maintenance

Wind turbines on floating substructures are typically mounted at port or in sheltered waters.

Subsequent component replacements and major O&M efforts often incur substantial cost and logistical challenges, whether such activity is carried out on-site or at shore after towing.

For floating wind, few viable crane solutions able to lift nacelles in the 10-15 MW size range on site have been developed. Indeed, this challenging type of marine operation typically requires motion compensation of load that adapts to the floater at nacelle height. The industry is looking for solutions to address such challenges, including the use of climbing crane solutions which utilize the wind turbines' own structure for load support.

For bottom-fixed structures, in Europe, such expertise is largely concentrated in Germany and the Netherlands.

But for floating offshore wind, processes and equipment needed to perform such heavy maintenance remain in early stages. Norwegian O&G industry players could leverage state-of-the-art solutions for offshore material handling and automation to address this type of need.

5.4.5 International moves underscore Norway's strengthening position as hub for commercialization of floating offshore wind technology

Despite the relative lack of a home market for offshore wind, Norway boasts several characteristics making it well placed as a hub for the development of floating offshore wind technology.

These include its high degree of industrialization, relevant competence from existing oil, gas and maritime industries, port infrastructure, favorable water depth conditions and increased political ambition to develop the sector.

Test centers such as the Marine Energy Test Centre (Metcentre) off Rogaland, the site of the first Hywind deployment in 2009, is key to tapping this potential. Indeed, a consortium consisting of leading European utilities Iberdrola and EDF EN was awarded a EUR 25 million grant in July 2020 for the development of the Flagship project which seeks to demonstrate semi-submersible concrete foundations supporting 10 MW offshore wind turbines at this site.

This grant and further moves into Norway by other leading European energy players including Shell and Innogy underscore the potential of Norway as an R&D hub for floating offshore wind.

6 CONCLUSION

The offshore wind industry has the potential to be one of Norway's most important industries in the future. Turnover for the Norwegian offshore wind supply chain in the Medium Base Case scenario is forecast to be 2.1 bn. EUR/year in the near term to 2025, increasing to 7.2 bn. EUR/year towards the end of the 2040s. All numbers are expressed in 2020 values.

Bottom-fixed offshore wind will remain the key source of revenue for Norwegian players, accounting for on average EUR 3 bn. in the 5-year period from 2026 to 2030 and EUR 5.3 bn. in the 2040s. Similarly, floating offshore wind makes up a mean of slightly below 800 MEUR/year in the 2026-2030 period and increases to an average of almost 2 bn. EUR in the decade leading up to 2050.

There is a significant upside in the Accelerated Growth scenario, where we believe Norwegian supply chain could capture up to 12.9 bn EUR/year by the end of the forecast period at the High (P70) end of the market range, 9 bn. EUR/year of which would be bottom-fixed developments. On the other hand, in the Slow Progression scenario, we estimate total Norwegian turnover is limited to 2.8 bn. EUR/year in the same period at the Low (P30) end of the market range.

The majority of turnover will be from the European market both for bottom-fixed and floating offshore wind. This region makes up for a mean revenue of 2.7 bn. EUR/year around 2030 and 3.7 bn. EUR/year in the 2040s or 72% and 51% of global opportunities for the Norwegian supply chain.

Opportunities for Norwegian companies are particularly strong within installation of both turbines and floating foundations, project development and management, HVDC export cables and offshore sub-stations, array cables, as well as marine operations, mooring systems for floating wind farms and within operation and maintenance of offshore wind farms. For the European market, the Norwegian supply chain can take a market share of up to 48% and above in the high market range in the Accelerated Growth scenario.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

7 APPENDIX I - METHODOLOGY: ASSESSMENT OF NORWEGIAN MARKET SHARES IN GLOBAL OFFSHORE WIND

7.1 Methodology

7.1.1 Definition of Norwegian Supply Chains Market Share per segment

The Market Share for the Norwegian Supply chain is defined as revenue from companies registered in Norway for its activities in Norway and third-party countries. The Market Size for Norwegian Market Shares have been shown in *Chapter 2* and *Chapter 3.* The market development is converted to investment profiles per regional market and disaggregated into market segments as presented in *Chapter 4.*

The Norwegian content is those described in market share and turnover. This means that:

- It includes any sub-contracting to other countries, so for example if a Norwegian owned company does the engineering in Norway, but the manufacturing in a third country, both the engineering part of the contract value and the manufacturing are included.
- If a large component such as a sub-station is partly manufactured in a third country and partly manufactured in Norway both the value creation added in Norway and the partly manufactured goods in the third country are included.
- If a Norwegian company is constructing a vessel that is operated in a third country by a third country personnel and port facilities outside Norway both the revenue associated with the purchased assets from Norway and the services provided are included if the shipping company is registered in Norway. If the shipping company is registered outside Norway only the revenue associated with the purchased assets from Norway are included.
- If conglomerate company is owned by a third country, but with an independent subsidiary in Norway that manufactures and/or make installation operated from Norway and/or with vessels operated from Norway, the value revenue is considered to be Norwegian.
- If a Norwegian developer is using third party sub-contractors in a foreign market but is otherwise doing the development and project management work in Norway, the assigned cost to head office functions in Norway is included, while the rest of the contract value is excluded.

The estimated market share is therefore the market share of the revenue of the Norwegian Supply Chain operating form Norway, which is different from the market share of value creation in socio-economic terms. The latter would have excluded activity outsources to third party countries and subsequently represented a smaller amount.

7.2 Qualitative assumptions by cost category

The qualitative assessment of the Norwegian market share has been conducted by an expert panel consisting for experienced Renewable Energy Professionals in Norway.

Development Expenditure

Several Norwegian companies, such as NGI, Storage, Scanmudring and Cognite, are capable of supplying services during project development, including offshore surveys, assessment of geology and metocean conditions. In addition, this category includes the activities conducted in-house within project developers. Equinor and Statkraft took part in the Forewind consortium for development of the shared projects at Dogger Bank, and Aker Offshore Wind is involved in early phase assessment of projects in South Korea and the USA. Several other developers, including Fred Olsen are currently looking at developing offshore wind domestically and internationally.

For domestic offshore wind projects, the Norwegian supply chain will most likely be able to achieve a very large market share. Conversely, as specialist consultancy services to a large degree are being sourced locally within each market, and the Norwegian market for bottom fixed is relatively small

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

compared to the rest of Europe. The mentioned companies along with new expected entries will nevertheless enable a Norwegian market share to take dominant position in Europe and s significant position in other regions. Nevertheless, since Norwegian developers such as Equinor on its own have a substantial market position, and large corporations are doing a lot of the development work internally, Norwegian industry can take a dominant market position in Europe and a significant position across other markets as reflected by the large portion of the development being carried out in Norway. In addition, Norway has a large O&G industry where many companies could enter the market. Especially for new entries a positive or negative climate under the Accelerated Growth or Slow Progression scenarios will impact the Norwegian share of development activities. Overall, the panel expects the opportunity for revenues in this segment is likely to only be somewhat impacted by the different sensitivity scenarios, since large corporations like Equinor still will carry out a portion of the development activities internally under all scenarios.

For floating wind, the opportunity for Norwegian Supply Chain is assumed to be higher, as companies such as Equinor and Aker are already leading the way, and the Norwegian supply chain offers substantial technological know-how within floating offshore structures. Further, new entries that can transfer O&G offshore experience are well placed to take a position in the floating development market. Floating wind is currently considered less competitive than the bottom fixed market. Therefore, the expert group assumes that these factors provide an opportunity for a dominant market position in both Europe and South-East Asia where several Norwegian companies are already having projects under development. Norwegian companies can also have a significant market share in the remaining regions. For similar reasons as for fixed the impact of the Slow Progression or Accelerated Growth scenario are considered to have some impact.

Construction Management can be viewed as an extension of development work with similar players and considerations. The same assessment has been done for all regions in terms of market position and impact from the two remaining scenarios.

Turbine Supply

No turbine manufacturers have production in Norway. Some sub-components produced by Dokka Fasteners and Øgland Systems, as well as fibreglass material from Birkeland Fibreglass, are exported to the international turbine OEM's. Control systems, electrical systems, and other instruments as well as composite materials are supplied to turbine manufacturers in Europe. Turbine Supply alone represents 33.6% of the entire offshore wind market and these sub-components are negligible in this context the Norwegian market share is set to nil for all geographical locations for both fixed and floating. The situation is not expected to change under any of the scenarios. Although it might be too late to influence the Norwegian market share for wind turbines this important segment nevertheless illustrate how early success in a small country such as Denmark with a current very large turbine manufacturers industry can conquer a dominant market share across all regions in a global market.

Norwegian industry also provides vessels for operation and maintenance. For the turbine shipping market, it is anticipated that Norwegian shipping companies can capture a significant share across most markets. As the turbine shipping market is a global market, it is expected that the sensitivity scenarios will have only some impact on the market shares in this segment.

Turbine Installation

This market has several Norwegian actors with global presence and is highly competitive in most countries except for USA where foreign built and operated vessels are excluded from transporting equipment from ports due to the Jones Act legislation.

For bottom-fixed turbines the Norwegian company Fred. Olsen Windcarrier has installed turbines in Europe, USA and now also in Asia, often in competition with Dutch and Belgian operators. This summer, two Norwegian actors, Ocean Installer and Offshore Heavy Transport (OHT) signed contracts for building large new Turbine Installation Vessels (TIV). Norwegian companies in this segment are assumed to take a dominant position in all regions except North America with a higher level of local supply chain. The Norwegian market share in North America is nevertheless expected to be significant. Fred Olsen alone has a very significant market share, and the expert panel considers even the levels defined as dominant to be a conservative estimate.

The market for installation of turbines on top of floating substructures is still immature and no specific methodology nor vessels are developed for such work. As concluded in a recent study published by the UK Carbon Trust, heavy lift vessels on the market in general have more than enough lifting capacity, but too short booms to install the largest turbines. Norway has however a leading position on floating offshore wind installation. In Europe deep fjords provide Norwegian industry with a geographical advantage. One of the first major floating offshore wind farms, Hywind Scotland, was assembled at Kværner, Stord before it was shipped to Scotland. The expert panel expects floating wind installation to need specialised equipment and Norwegian industry is well positioned to take a dominant share in floating offshore wind installation, even in North America as domestic players might find it harder to compete with Norwegian suppliers.

The impact from the sensitivity scenarios on the installation market for both fixed and floating is expected to be considerable for all regions, as this is an area with significant technology development, and being early movers is considered an advantage. In addition, low oil prices (as per the Accelerated Growth scenario) will push actors to look for opportunities in offshore wind. In the Accelerated Growth scenario, Norwegian players are expected to be able to take a dominant position in this market segment in several regions.

Foundation Supply – Fixed

For bottom-fixed, several foundation concepts exist, with the most usual being monopile, jackets and GBS structures. Monopiles are by far the most common technology, for which there are currently no Norwegian suppliers. Monopile fabrication requires large investment in production facilities. Dutch and German companies have so far supplied monopiles to most of the European market, and a South Korean steel manufacturer is currently setting up production facilities in the UK.

Kværner Verdal fabricated 48 jacket structures for a German wind farm and Owec Tower has designed jacket structures for several projects. Steel structure fabrication require some permanent yard facilities that not all domestic markets can offer.

Norway has a world leading position within design of very large GB structures for the oil and gas industry, and SeaTower AS has demonstrated a float-out-and-sink foundation for a meteorological mast in France. Concrete structures offer the ability to support local industry in the country where the wind farm is located which also then make these foundations less competitive for export to foreign markets. However, Kværner has experience of setting up local facilities and such a strategy can involve Norwegian industry abroad. GB structures and jackets may be more suitable for the soil conditions in Crown Estates round 4 as well as the ScotWind allocation round of offshore wind. GB structures are also planned for the Equinor owned Empire Wind project in the US, with the help of local suppliers for the concrete.

Larger wind turbines and water depths may result in bigger market shares for alternative solutions, however, monopiles have proven to be resilient and are still viable for increasing water depths and turbine sizes. The break point for jackets or other solutions going forwards is uncertain. As such, the expert panel considers this estimate to be highly dependent on the technology employed. In summary, a Norwegian market share for supply of fixed foundations is anticipated to remain moderate in Europe and nil elsewhere. As mentioned, the Norwegian market share is expected to be heavily restricted by the prevalence of the monopile technology. The market share is therefore not expected to be influenced by which of the sensitivity scenarios that materialise.

Foundation Supply – Floating

For the floating market, Norwegian supply chain actors are active in several areas. All three Hywind projects' substructures include Norwegian engineering, fabrication, and installation services as this technology requires deep fjords less available in other European countries. Norwegian companies are also positioned to take market shares with technologies not dependent on deep fjords. The

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

opportunity is conservatively assessed to reach the levels of a dominant position in Europe. Elsewhere in the world the floating structures will need to be manufactured locally, but there is a role for Norwegian companies to play in licencing and engineering of such structures, hence the Norwegian market share is assessed to be considerable in markets outside Europe as well. Further, the Norwegian market share for Sub-structures for floating offshore wind are expected to be considerably dependent on which of the Slow Progression or Accelerated Growth scenarios that materialise.

Foundation Installation - Fixed

Historically, the Norwegian involvement in foundation installation has been low. However, the Norwegian shipping company OHT is now building an Ulstein designed semi-submersible installation vessel that will install monopiles at the Dogger Bank wind farm in UK. In addition to vessel design, installation equipment, such as pile grippers and compensated access systems has been developed in Norway. With an increasing number of specialised vessels, the Norwegian industry is considered to be able to take a considerable market share in Europe and a relatively international market will enable them to take a similar market share elsewhere. This is a mature market segment, and as such, the potential market share is expected to be only somewhat impacted by the two sensitivity scenarios.

Floating Moorings Supply

Anchors, suction buckets, fairleads and winches are typical products that Norwegian companies have supplied to the O&G industry, and it is therefore likely that the same actors can be dominant in this segment for the European offshore wind market as well. Norwegian companies can benefit from patents as well as engineering from Norwegian based companies and use this base to take a significant market share the regions further away. Steel chains represent a large portion of the cost for mooring solutions and are typically sourced from a globally active, and competitive market. The industry is testing use of synthetic fibre ropes and Sintef is taking part in the EU-funded project MooringSense which can increase the Norwegian market share. The mooring and anchor solutions are under development and a Slow Progression or Accelerated Growth scenario could those significantly impact the position of the Norwegian Supply Chain in this market.

Floating Marine Operations

Only a few floating offshore wind turbines have so far been installed worldwide and as several substructure designs are still being developed, the marine operation principles are not standardized. However, as Equinor and the Hywind concept is in a leading position, the Norwegian Supply Chain has been given a head start and have already taken a dominant position. Norwegian companies are also benefiting from the O&G legacy. A good starting position may be further exploited, and the Norwegian vessel operators are considered to take a dominant position in all markets except for North America where they are considered to take a significant position due to some restrictions from the Jones Act. The impact from Slow Progression or Accelerated Growth scenarios are considered to be significant, as this market is still immature and is therefore open for new entrants.

Array Cables – Supply and Installations

Array cables (the cables connecting the Wind Turbines to the Sub-station) are often delivered as EPCI contracts where Dutch companies are dominating with Norwegian sub-suppliers of physical cables. The Nexans factory in Rognan is producing fibre optic cables and Draka (now owned by Prysmian) in Drammen have delivered inter-array cables to several wind farms. Siem Offshore is a well-established actor within inter array cable installation, however Dutch trenching vessels are typically used. Since the installation scope represents a larger portion than the cable supply, and this is an international market, Norwegian marine contractors should have a significant possibility to compete in this market. Despite higher competition from local suppliers in South East Asia the opportunity is considered to be significant for all regions apart from North America where the

Norwegian Supply Chain have taken a moderate position due to protectionist legislation and the ease of developing a local supply chain. This is not expected to be impacted by any of the two scenarios.

Floating turbines require flexible (dynamic) cables. There are fewer suppliers with know-how and track record within this technology. Aker Solutions and Unitech are examples of Norwegian companies with capabilities in this segment. The expert panel considers that the Norwegian Supply Chain can take a dominant position for floating wind within this segment across all markets except North America due to some restrictions imposed by the Jones Act. Further, the impact from the sensitivity scenarios are expected to be considerable, as demonstrating track record from deploying dynamic cables in the domestic market would strengthen Norwegian suppliers' chances in the global market.

Export Cable

Export cables are typically procured through EPCI contracts where supply and installation are similar size in terms of value. Nexans' factory in Halden has delivered export cables to major wind farm developers, but Nexans installation vessels are operated from France. A fabrication facility in USA is under planning. A new installation vessel Nexans Aurora, which is designed by Ulstein, enters the market in 2021. The Norwegian Supply Chain is therefore expected to start taking a share of the installation market as well. Nexans Norge's position is considerable, and the expert panel assess the Norwegian Supply Chain to take a dominant position for marine AC fixed cables to be high in Europe and significant position elsewhere for both floating and fixed. The two scenarios could have some impact on the fixed market share and considerable impact on the floating market share for Norwegian industry where it could benefit from its capabilities and track record of installing dynamic cables and flexible risers in the O&G sector. Demonstrating track record from deploying dynamic cables in the domestic market would strengthen Norwegian suppliers' chances in the global market.

The market for onshore cable installation is dominated by domestic supply chains. The opportunity for supply of onshore cables is considered to be significant for Europe and moderate elsewhere with no impact form the sensitivity scenarios.

The DC export cable market is much more global in character. Even USA is considered to be too small for a domestic market. Subsequently, it is expected that Nexans Norge will continue to take a dominant position in the global market for both fixed and floating (if developed in the future), with some more competition in Asia where regional suppliers have a larger market share, but where Nexans Norge can still take a significant market share. The market is relatively mature and is not likely to be impacted by any of the two remaining scenarios.

AC OSS, OnSS Electrical & Civil

Norwegian suppliers have so far supplied only minor equipment to AC substations (onshore and offshore). This market is dominated by large players such as ABB and Siemens.

However, floating substations are exposed to movements and acceleration forces that will require special considerations. The Norwegian Supply Chain has a track record within floating structures.

It is assumed that companies such as Aibel and Aker Solutions are well positioned to deliver floating substations if this becomes a demand. Companies such as Moss Maritime can provide services within design. As such, this area presents an interesting opportunity for the Norwegian Supply Chain, where it is considered that Norwegian players could take a dominant role, especially in Europe. In other regions, more competition is expected from local players, however, the Norwegian supply chain can still take significant positions. The impact in the different sensitivity scenarios is considered to be significant for the floating market, as demonstrating track record from deploying floating substations in the domestic market would strengthen Norwegian suppliers' chances in the global market.

OSS Foundation

The Norwegian share of this market is currently limited to HVDC platforms. Aibel delivered the Dolwin beta offshore HVDC platform to Germany and is currently constructing the HVDC substations for the UK Dogger Bank projects owned by Equinor and SSE. The structures of the OSS are manufactured outside Norway with the outfitting taking place at Aibel's facilities in Haugesund. Hence, the Norwegian content does not represent the entire contract value, however, still constitutes a large share. As this analysis considers the complete contract value, the opportunity is not affected by this. It is considered that Aibel's large market share in Europe will continue, and that more Norwegian players will enter the market. As for other markets, it is unclear if the outfitting will be carried out to the same extent in Norway, and Norwegian content may be limited to project management, design and engineering. Other Norwegian companies such as Aker and Kværner could also participate in this market utilising their experience from O&G. The Norwegian Supply Chain can take a dominant share of the European market and a significant share in other markets both for floating and fixed wind turbines. However, the impact from the scenarios on the more immature floating market is considerable with some impact on the bottom-fixed market as well.

The market for shipping out of Europe is considered to be considerable, with Norwegian companies such as Offshore Heavy Transport and other shipping companies in Norway taking a large share of the markets. The sensitivity scenarios are considered to only have some impact across all regions within this segment, as this is already a global marketplace, but fluctuations in the O&G market can force players to focus more on the renewable market.

AC OnSS Elec Civil and DC Electrical Component

This market is dominated by ABB and Siemens situated outside Norway. Only a negligible Norwegian content on a sub-contractor level is anticipated across all regions with no impact from the sensitivity scenarios.

Other Capex

This category includes legal fees, financial fees, environmental costs, and additional nontechnical content. Norway's largest banks, DNB and Nordea, both have a large position in international shipping and the O&G offshore industry. These banks as well as regional banks can take a position in the global market. Norwegian companies such as Cognite and Kongsberg have delivered software service to the O&G offshore industry. Increasing digitalisation in the offshore wind industry could help the offshore wind industry in general and the floating industry in particular. Much of this segment is, however, dominated by domestic industry. The Norwegian market share could be significant for Europe and moderate for other regions for fixed and Norwegian companies could take a dominant position in Europe and get a significant market share for floating. These market shares are expected to be somewhat impacted by the scenarios.

Financial services also represent the margin the financial sector earns on loan financing. It can be either through the Treasury centre for large corporations like Equinor or Norwegian banks funding Norwegian developers. The same assessment has been done for the margin earned by banks or internal treasury centres as for the other capex category.

Accounting, HR services and other administrative tasks are mainly done domestically although large companies, such as Equinor, will provide some head quarter services to their local subsidiaries. It is therefore anticipated that the Norwegian market share can be significant for Europe with many projects owned by Norwegian developers and moderate for other regions, with some impact from the sensitivity scenarios.

Operational Expenditure

This segment includes the operational cost of service operation vessels (SOVs), the O&M of generation assets, export cable opex, offshore and onshore substation opex and operating insurance. Whereas the cost for service personnel, operation centres and harbours etc. are typically local, the other services can be supplied by international players. Norwegian players already have a strong position for supply of vessels. The O&G legacy leaves a presence in Brasil and Norway has a substantial shipping industry in Asia. The Fred. Olsen company Global Wind Service is a major actor. Other shipping companies are Edda providing Offshore Supply vessels and Østensjø Rederi, Norwegian industry is also supporting the O&M indirectly through the procurement of supply ships. This opportunity is therefore assumed to be significant in most markets for operation and maintenance of wind farms, and they can take a dominant position in Europe to reflect Norwegian operation bases and local content in the Norwegian offshore wind market, with some impact from the scenarios.

As for the operation insurance market Norway does not have a large financial sector in general, GAAR, DNB and Nordea specialise in the insurance market for shipping. The panel therefore thinks Norwegian insurance providers can take a moderate market share in a global insurance market, with some impact from the sensitivity scenarios.

Abandonment Expenditure

Since offshore wind is a young industry the market for decommissioning is limited today, however it is likely to grow at the end of the projected timeline. Norwegian companies that have experience from decommissioning and abandonment of O&G assets on the Norwegian continental shelf and are well placed to take a dominant market share in Europe and significant market share elsewhere for both the fixed and the floating industry. It is expected that it is somewhat impacted by the Slow Progression or the Accelerated Growth scenario.

7.3 Summary of assumptions on Norwegian market shares by technology and market

The qualitative assessment of Norwegian opportunities was based on the structure of RCG's database. This detailed approach encompassed 36 segments across 16 categories. For each of the segments, a likely market share of Norwegian suppliers was assessed. For completeness, these considerations are presented in the two tables below.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

7.3.1 Bottom-fixed offshore wind

Table 6 - Assessment of bottom-fixed OSW market share potentials for Norwegian suppliers

Fixed Foundation	Europe (incl. Russia)	North America	South America	Middle Eeast	China	South East Asia (excl. China)	Australia/ New Zealand	Africa	Summary category
DevEx	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	DevEx
Turbine Supply	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Turbine Supply
Turbine Shipping	N/A	Significant	Significant	Significant	Nil	Significant	Significant	Significant	
Turbine Installation	Dominant	Significant	Dominant	Dominant	Nil	Dominant	Dominant	Dominant	Turbine Installation
Foundation Supply	Moderate	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Foundation Supply
Substructure Supply *(floating projects only)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Foundation Shipping	N/A	Moderate	Significant	Significant	Nil	Significant	Significant	Significant	
Foundation Installation	Significant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	Fixed Foundation Installation
Moorings Supply *(floating projects only)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Floating Moorings Supply
Marine Operations *(floating projects only)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Floating Marine Operations
Array Cable Total	Significant	Moderate	Significant	Significant	Nil	Moderate	Significant	Significant	Array Cable
AC Offshore Export Cable Total	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	Export Cable
AC Onshore Export Cable Total	Significant	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	
DC Export Cable Main	Dominant	Dominant	Dominant	Dominant	Nil	Significant	Dominant	Dominant	
DC Export Cable Auxiliary	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
AC OSS Topside Supply	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	OSS/OnSS Electrical & Civil
AC OSS Total Shipping	N/A	Significant	Significant	Significant	Nil	Significant	Significant	Significant	
AC OnSS Elec Civil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
DC Electrical Component	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
DC OSS Total Shipping	N/A	Significant	Significant	Significant	Nil	Significant	Significant	Significant	
DC OSS Foundation	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	OSS Foundation
AC OSS Foundation	Moderate	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	
Construction Management	Significant	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	Other CapEx
Other Capex	Significant	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	
Contingency Capex	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Insurance Capex	Moderate	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	
Generation Opex	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	Opex
Export Cable Opex	Moderate	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
OSS Total Opex	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
OnSS Total Opex	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Operating Insurance	Moderate	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	
Gen Abex	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	Decommissioning
TS Abex	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	
Financial services Opex	Moderate	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Other Opex
Administration (Accounting, HR, etc) Opex	Significant	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	
Administration (Accounting, HR, etc) Capex	Significant	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	Other Capex

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

7.3.2 Floating offshore wind

Table 7 - Assessment of floating OSW market share potentials for Norwegian suppliers

Floating Sub-structure	Europe (incl. Russia)	North America	South America	Middle Eeast	China	South East Asia (excl. China)	Australia/ New Zealand	Africa	**Summary category**
DevEx	Dominant	Significant	Significant	Significant	Nil	Dominant	Significant	Significant	DevEx
Turbine Supply	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Turbine Supply
Turbine Shipping	N/A	Significant	Significant	Significant	Nil	Significant	Significant	Significant	
Turbine Installation	Dominant	Significant	Dominant	Dominant	Nil	Dominant	Dominant	Dominant	Turbine Installation
Foundation Supply	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Foundation Supply
Substructure Supply *(floating projects only)*	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	
Foundation Shipping	N/A	Moderate	Significant	Significant	Nil	Significant	Significant	Significant	
Foundation Installation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Fixed Foundation Installation
Moorings Supply *(floating projects only)*	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	Floating Moorings Supply
Marine Operations *(floating projects only)*	Dominant	Significant	Dominant	Dominant	Nil	Dominant	Dominant	Dominant	Floating Marine Operations
Array Cable Total	Dominant	Significant	Dominant	Dominant	Nil	Significant	Dominant	Dominant	Array Cable
AC Offshore Export Cable Total	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	Export Cable
AC Onshore Export Cable Total	Significant	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	
DC Export Cable Main	Dominant	Dominant	Dominant	Dominant	Nil	Significant	Dominant	Dominant	
DC Export Cable Auxiliary	Moderate	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
AC OSS Topside Supply	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	OSS/OnSS Electrical & Civil
AC OSS Total Shipping	N/A	Significant	Significant	Significant	Nil	Significant	Significant	Significant	
AC OnSS Elec Civil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
DC Electrical Component	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
DC OSS Total Shipping	N/A	Significant	Significant	Significant	Nil	Significant	Significant	Significant	
DC OSS Foundation	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	OSS Foundation
AC OSS Foundation	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	
Construction Management	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	Other CapEx
Other Capex	Significant	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	
Contingency Capex	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Insurance Capex	Moderate	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	
Generation Opex	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	Opex
Export Cable Opex	Moderate	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
OSS Total Opex	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
OnSS Total Opex	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Operating Insurance	Moderate	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	
Gen Abex	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	Decommissioning
TS Abex	Dominant	Significant	Significant	Significant	Nil	Significant	Significant	Significant	
Financial services Opex	Moderate	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Other Opex
Administration (Accounting, HR, etc) Opex	Significant	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	
Administration (Accounting, HR, etc) Capex	Significant	Moderate	Moderate	Moderate	Nil	Moderate	Moderate	Moderate	Other Capex

7.4 Impact of Slow Progress and Accelerated Growth scenarios from Base Case scenario

The Base Case assumes the mid-range within for the Dominant, Significant or Moderate market position. The impact matrixes below show how RCGN have assessed the impact of a Slow Progression scenario or an Accelerated Growth scenario. The segments effected are identical for both scenarios, but the outcome is negative compared to base case for the Slow Progression scenario and positive for the Accelerated Growth scenario.

Table 8 Impact from Slow Progress or Accelerated Growth on Bottom-Fixed OSW from Base Case Scenario

Impact Fixed Foundation	Europe (incl. Russia)	North America	South America	Middle Eeast	China	South East Asia (excl. China)	Australia/ New Zealand	Africa	Summary category
DevEx	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	DevEx
Turbine Supply	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	Turbine Supply
Turbine Shipping	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Turbine Installation	Considerable impa	Considerable impact	Considerable impact	Considerable impact	No impact	Considerable impact	Considerable impact	Considerable impact	Turbine Installation
Foundation Supply	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	Foundation Supply
Substructure Supply *(floating projects only)*	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	
Foundation Shipping	Not applicable	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
Foundation Installation	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	Fixed Foundation Installation
Moorings Supply *(floating projects only)*	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Floating Moorings Supply
Marine Operations *(floating projects only)*	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Floating Marine Operations
Array Cable Total	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	Array Cable
AC Offshore Export Cable Total	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	Export Cable
AC Onshore Export Cable Total	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
DC Export Cable Main	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
DC Export Cable Auxiliary	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
AC OSS Topside Supply	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	OSS/OnSS Electrical & Civil
AC OSS Total Shipping	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
AC OnSS Elec Civil	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
DC Electrical Component	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
DC OSS Total Shipping	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
DC OSS Foundation	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	OSS Foundation
AC OSS Foundation	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Construction Management	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	Other CapEx
Other Capex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Contingency Capex	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	
Insurance Capex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Generation Opex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	Opex
Export Cable Opex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
OSS Total Opex	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
OnSS Total Opex	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
Operating Insurance	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Gen Abex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	Decommissioning
TS Abex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Financial services Opex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	Other Opex
Administration (Accounting, HR, etc) Opex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Administration (Accounting, HR, etc) Capex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	Other Capex

Table 9 Impact from Slow Progress or Accelerated Growth on Floating OSW from Base Case Scenario

Impact Floating Sub-structure	Europe (incl. Russia)	North America	South America	Middle Eeast	China	South East Asia (excl. China)	Australia/ New Zealand	Africa	Summary category
DevEx	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	DevEx
Turbine Supply	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	Turbine Supply
Turbine Shipping	Considerable impact	Considerable impact	Considerable impact	Considerable impact	No impact	Considerable impact	Considerable impact	Considerable impact	
Turbine Installation	Considerable impact	Considerable impact	Considerable impact	Considerable impact	No impact	Considerable impact	Considerable impact	Considerable impact	Turbine Installation
Foundation Supply	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Foundation Supply
Substructure Supply *(floating projects only)*	Considerable impact	Considerable impact	Considerable impact	Considerable impact	No impact	Considerable impact	Considerable impact	Considerable impact	
Foundation Shipping	Not applicable	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
Foundation Installation	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Fixed Foundation Installation
Moorings Supply *(floating projects only)*	Considerable impact	Considerable impact	Considerable impact	Considerable impact	No impact	Considerable impact	Considerable impact	Considerable impact	Floating Moorings Supply
Marine Operations *(floating projects only)*	Considerable impact	Considerable impact	Considerable impact	Considerable impact	No impact	Considerable impact	Considerable impact	Considerable impact	Floating Marine Operations
Array Cable Total	Considerable impact	Considerable impact	Considerable impact	Considerable impact	No impact	Considerable impact	Considerable impact	Considerable impact	Array Cable
AC Offshore Export Cable Total	Considerable impact	Considerable impact	Considerable impact	Considerable impact	No impact	Considerable impact	Considerable impact	Considerable impact	Export Cable
AC Onshore Export Cable Total	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
DC Export Cable Main	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
DC Export Cable Auxiliary	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
AC OSS Topside Supply	Considerable impact	Considerable impact	Considerable impact	Considerable impact	Considerable im	Considerable impact	Considerable impact	Considerable impact	OSS/OnSS Electrical & Civil
AC OSS Total Shipping	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
AC OnSS Elec Civil	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
DC Electrical Component	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
DC OSS Total Shipping	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
DC OSS Foundation	Considerable impact	Considerable impact	Considerable impact	Considerable impact	No impact	Considerable impact	Considerable impact	Considerable impact	OSS Foundation
AC OSS Foundation	Considerable impact	Considerable impact	Considerable impact	Considerable impact	No impact	Considerable impact	Considerable impact	Considerable impact	
Construction Management	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	Other CapEx
Other Capex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Contingency Capex	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	
Insurance Capex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Generation Opex	Considerable impact	Considerable impact	Considerable impact	Considerable impact	No impact	Considerable impact	Considerable impact	Considerable impact	Opex
Export Cable Opex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
OSS Total Opex	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
OnSS Total Opex	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact	
Operating Insurance	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Gen Abex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	Decommissioning
TS Abex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Financial services Opex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	Other Opex
Administration (Accounting, HR, etc) Opex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	
Administration (Accounting, HR, etc) Capex	Some impact	Some impact	Some impact	Some impact	No impact	Some impact	Some impact	Some impact	Other Capex

8 APPENDIX II – OFFSHORE WIND CONTRACTS

8.1 Typical offshore wind contract

Individual differences exist on a project-by-project basis, but there are standard contracting structures associated with the construction phase of offshore wind farms which are utilised by project development teams.

Each of these conventions has inherent strengths and weaknesses and provide alternative balance of risk and cost. The most appropriate option for an individual project will depend on several key factors including but not limited to:

- Development scope driven by market conditions i.e. within the Danish and Dutch market, transmission system scope belongs to the local Transmission System Operator (TSO) and not the developer.
- Experience, capability, and market position of the project team.
- Experience and risk appetite of project owners, investors, and lenders.
- The project location and maturity of the local offshore wind sector.
- Availability of contractors, vessels and other equipment and resources.

There are three distinct contractual structures which have been used during the construction of offshore wind farms to date. Early in the development of the offshore wind sector single EPCI wrap arrangements were popular; however, as confidence in the sector grew developers began to separate out individual work packages, resulting in a multi-EPCI or full multi-contract approach. At this stage in the offshore wind industry, all three of these strategies are being implemented.

Capital expenditure (Capex) targets will play an intrinsic role in selecting a contracting structure. For example, multi-contract structures have been implemented by project companies as a Capex reducing measure and offer greater visibility and control of project risks.

Irrespective of contract model, project companies are ultimately responsible to some extent for managing contract interfaces. Interfaces vary in number depending on the selected contractual strategy and can be numerous under multi-contract arrangements. Project management best practice considers the implementation of interface and risk management plans which seek to minimise the impact of issues arising from multiple contract interfaces.

The following construction contract strategies are covered within the following sections:

1. Single EPCI wrap
2. Multi-EPCI
3. Multi-contract

Single EPCI wrap:

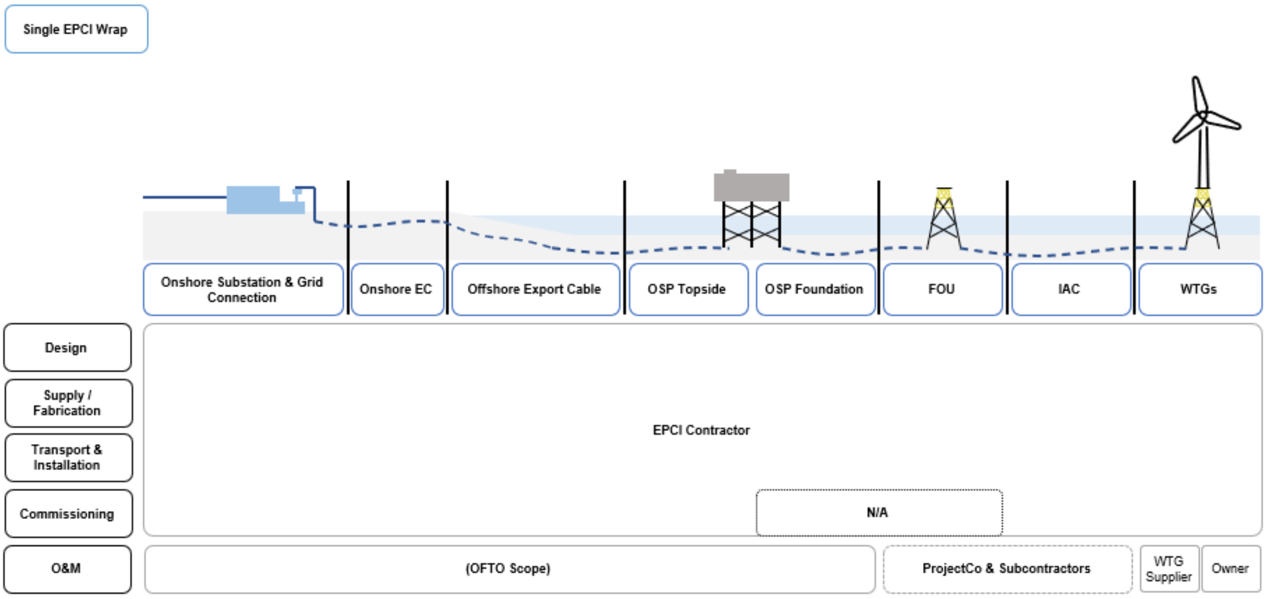
In a single EPCI wrap model, all construction and installation work packages are bundled together and contracted out to an individual contractor which can in turn subcontract out large parts of its scope (subject to specific subcontracting terms). Under this arrangement, the project company enters a single EPCI contact for delivery of the whole project from design to construction completion.

Developer profile: Only highly experienced EPCI contractors are able to follow this model and it is much more likely that contracts are split between a number of individual EPCI contractors with specific expertise.

A typical arrangement for a single EPCI wrap model is included in Figure 36 below.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

Figure 36 Single EPCI wrap contracting structure



Multi EPCI:

In a multi EPCI model, construction packages are bundled together and contracted out to multiple contractors, again each of which may in turn subcontract out some elements of their scope which they are not necessarily experienced in. Under this arrangement, the project company enters several individual EPCI contracts which are typically vertically integrated for the delivery of separate work packages.

This model can take various formats depending on the specific package split between contracts. As way of an example which has seen utilised in practice, there may be an EPCI contract for WTG supply and installation, another for supply and installation of transmission assets and a third for supply and installation civil works and inter-array cables.

Developer profile: This model may be adopted by developers seeking to minimise risk exposure (project delay, Capex and interface) by transferring these to the small number of EPCI contractors.

A typical arrangement for a multi EPCI model which is split into WTG and balance of plant (BoP) packages (onshore and offshore) is included within Figure 37 below. As stated, construction work packages can be split in any number of ways under a multi EPCI approach, Figure 38 highlights a practical variation of this contracting structure.

Figure 37 Multi EPCI contracting structure

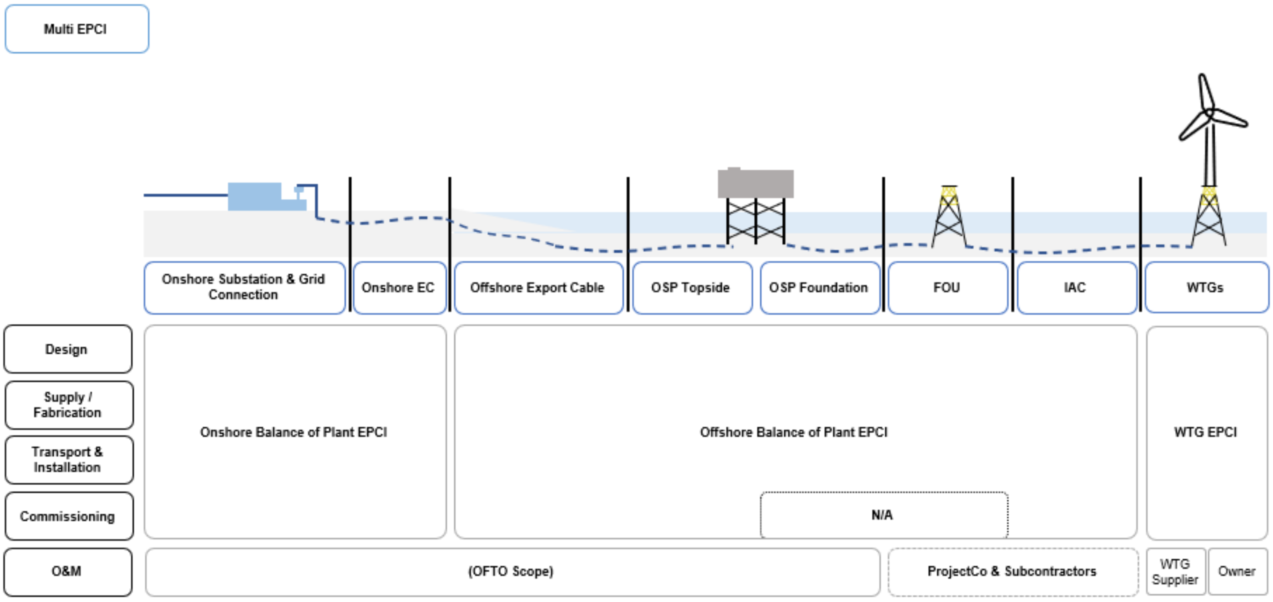
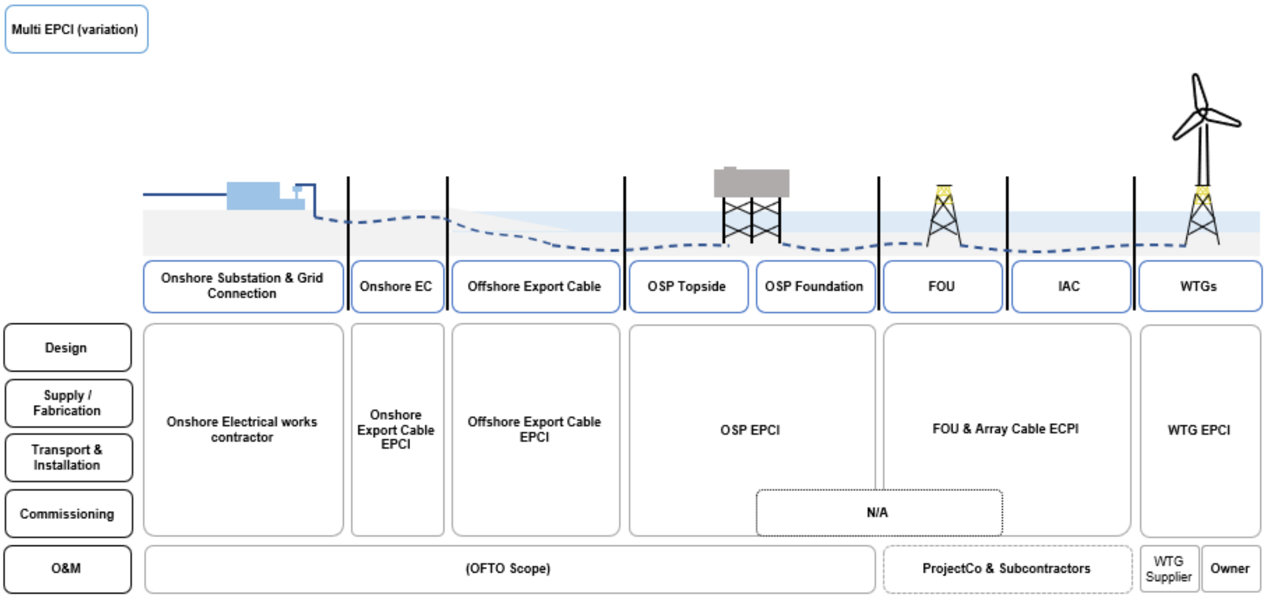


Figure 38 Multi EPCI contracting structure variation



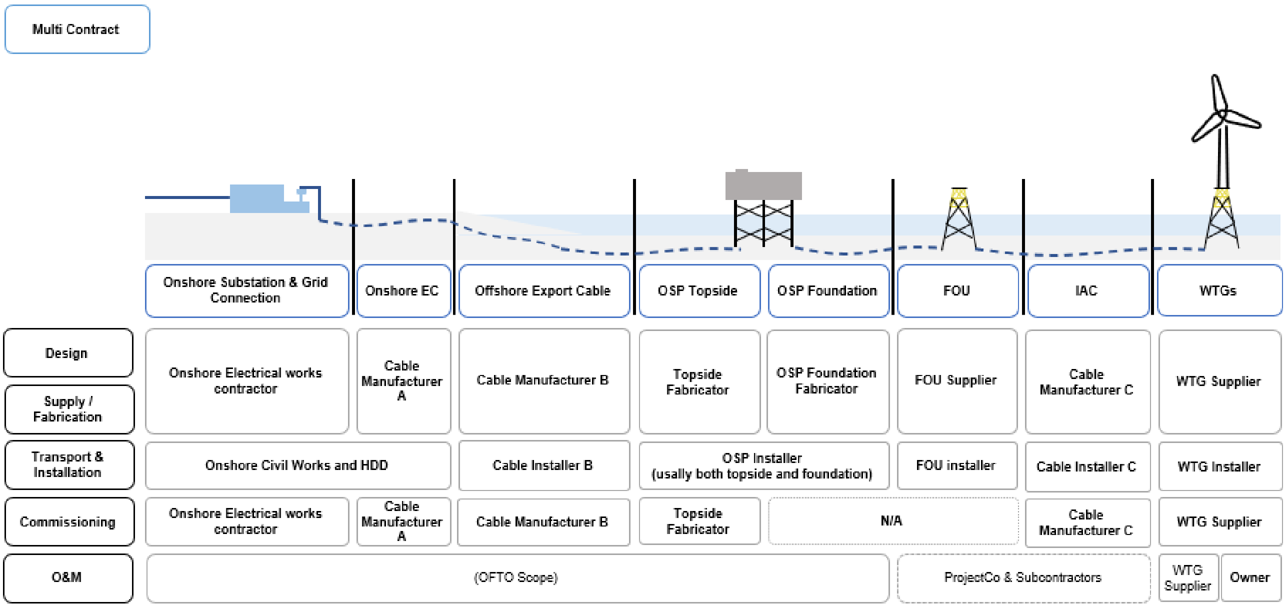
Multi Contract:

In multi contract arrangements, developers allocate individual construction work packages to individual contractors who will be specifically expert in that applicable package. Although developers will be exposed to increased risk and responsibility under this model, it is able to directly manage the construction phase with high visibility.

Developer profile: Higher visibility and control over the individual elements of the construction scope make this model attractive for developers seeking Capex savings vs. EPCI structures. Developers are more involved and extensive experience within the offshore wind sector and established interface/risk management systems are typically required.

A typical arrangement for a multi contract model which is split into WTG and BoP packages is included within Figure 39 below.

Figure 39 Multi Contract contracting structure



9 APPENDIX III - DETAILED DESCRIPTION OF OFFSHORE WIND SECTOR REPORTS' ASSESSMENT CONDUCTED IN CHAPTER 4

9.1 Assessment of other report's findings and conclusions

During the last few years, several studies have assessed the Norwegian possibilities within offshore wind, some generic and others with focus on floating wind only. In some of these reports, we have been able to find several topics described and structured in a similar way as our own study and we have applied a green, yellow and red colouring in the respective table columns to indicate and visualise the Norwegian supply chain's assumed strength or opportunity in the various segments. For example, if a report concludes that the Norwegian supply chain has, or most likely will manage to take a strong position within export cable production and installation, this section has been marked green. Likewise, a red cell implies either that Norway's suppliers face overwhelming competition or that the sector is already in the hands of incumbents from other country with practically no prospects for Norwegian companies to capture market shares.

Table 10 below is showing a summary of the studies' findings about the Norwegian offshore wind supply chain. The columns are grouped together to visualize in which segment most of the reports have concluded a strong or weak position for Norway.

Table 10 Summary of studies describing Norwegian supply chain activities in the offshore wind sector

SEGMENT	MENON 2019 (FLOATING ONLY)	THEMA, MULTICONSULT, FUTURE TECHNOLOGY 2019 (FLOATING ONLY).	MAKE 2016	STYRINGSKOMITEEN FOR GRØNNE ELEKTRISKE VERDIKJEDER 2020 (NHO)	BVG ASSOCIATES 2019
Devex			**NA**		
Turbine Supply					
Turbine Installation				**NA**	
Foundation Supply				**NA**	
Fixed Foundation Installation	**NA**	**NA**		**NA**	
Floating Moorings Supply			**NA**	**NA**	
Floating Marine Operations				**NA**	
Array Cable					
Export Cable					
OSS/OnSS Electrical & Civil				**NA**	
OSS Foundation				**NA**	
Other Capex			**NA**		
Opex					

From this summary, it seems to be a common understanding that Norway has best opportunities and capability to be successful within cable supply and installation, substation and WTG foundations supply and installation, as well as for Devex- and Opex-related work.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

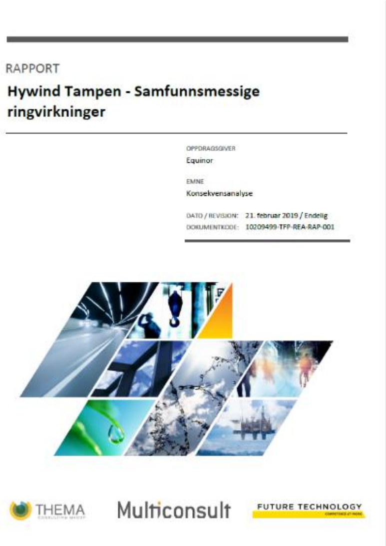
It should also be noted that the five reports that are presented individually in the following pages vary in both size and depth and that the BVG Associates' report is the most comprehensive study for supply chain assessment. Furthermore, as the floating wind industry has gained stronger momentum even during the last year - this might not have been captured as it would have been today.

Note: This is a high-level qualitative assessment primarily extracted from conclusions and main findings of the reports. Nonetheless, the findings give a good indication about the competences and strengths of the Norwegian offshore wind supply chain and flow into our Expert Group assessment of global value chain creation opportunities in chapter 5. More details about the individual reports are to be found in the appendix chapter.

<table>
<tr><th>MENON (2019) (FLOATING ONLY)</th><th>SEGMENT</th><th>COMMENTS</th></tr>
<tr><td rowspan="14">VERDISKAPINGSPOTENSIALET KNYTTET TIL UTVIKLINGEN AV EN NORSKBASERT INDUSTRI INNEN FLYTENDE HAVVIND

Main Conclusions:
Highlights the need of a strong domestic market, urges the importance of taking early position, a clear vision from authorities and attractive support schemes.
Competitive advantage is strongly linked to geography and market's requirements of using local content.
Turbine production is "already taken by others" and hence less of an opportunity for the Norwegian supply chain.</td><td>Devex</td><td>Linked to Norwegian concept development capability</td></tr>
<tr><td>Turbine Supply</td><td>A few successful tier 3 suppliers</td></tr>
<tr><td>Turbine Installation</td><td>Depending on geography and local presence</td></tr>
<tr><td>Foundation Supply</td><td>Depending on geography and local presence</td></tr>
<tr><td>Fixed Foundation Installation</td><td>NA</td></tr>
<tr><td>Floating Moorings Supply</td><td>Steel-chain supply dominated by others</td></tr>
<tr><td>Floating Marine Operations</td><td>Depending on geography. Companies with global presence are more competitive</td></tr>
<tr><td>Array Cable</td><td>Large potential in dynamic cable technology</td></tr>
<tr><td>Export Cable</td><td>High transportation cost to distant markets</td></tr>
<tr><td>OSS/OnSS Electrical & Civil</td><td>Depending on cooperation with electrical equipment providers</td></tr>
<tr><td>OSS Foundation</td><td>Depending on geography and local presence</td></tr>
<tr><td>Other Capex</td><td>Strong on project development, concept development and management.</td></tr>
<tr><td>Opex</td><td>Depending on geography. Companies with global presence can be competitive</td></tr>
<tr><td>Abex</td><td>NA</td></tr>
</table>

<table>
<tr><th>THEMA, MULTICONSULT, FUTURE TECHNOLOGY (2019) (FLOATING ONLY).</th><th>SEGMENT</th><th>COMMENTS</th></tr>
<tr><td rowspan="14">HYWIND TAMPEN - SAMFUNNSMESSIGE RINGVIRKNINGER



Main Conclusion:

“Hywind Tampen is likely to yield innovation and learning effects that contribute to commercialising floating offshore wind technology. Participation in the project by Norwegian suppliers could strengthen the competitive positioning of these in the broader national and international market. This should be given considerable weight in evaluations of the project by whomever it may concern.”</td><td>Devex</td><td>Project development, concept development and management</td></tr>
<tr><td>Turbine Supply</td><td>A few successful tier 3 suppliers</td></tr>
<tr><td>Turbine Installation</td><td>Depending on geography and timing</td></tr>
<tr><td>Foundation Supply</td><td>Large uncertainty in estimate and depending on timing</td></tr>
<tr><td>Fixed Foundation Installation</td><td>NA</td></tr>
<tr><td>Floating Moorings Supply</td><td>Moderate, but low for steel-chain supply</td></tr>
<tr><td>Floating Marine Operations</td><td>Depending on timing for establishment of a Norwegian home market</td></tr>
<tr><td>Array Cable</td><td></td></tr>
<tr><td>Export Cable</td><td></td></tr>
<tr><td>OSS/OnSS Electrical & Civil</td><td>Depending on timing</td></tr>
<tr><td>OSS Foundation</td><td>Depending on timing</td></tr>
<tr><td>Other Capex</td><td>Project development, concept development and management</td></tr>
<tr><td>Opex</td><td>For a Norwegian home market</td></tr>
<tr><td>Abex</td><td>NA</td></tr>
</table>

MAKE (2016)

NORWEGIAN OPPORTUNITIES IN OFFSHORE WIND

Main conclusions:

“Norwegian companies have proved to be competent in the turbine installation, operations and maintenance, shipyards and cable segments, but have so far failed to significantly establish themselves in the turbine supply as well as the foundation and substation segments”.

“However, in recent years Norwegian shipyards have developed and built innovative vessels for the O&M segment. These vessels are meeting requirements for longer operations, increased distance to shore and harsh weather conditions”.

SEGMENT	COMMENTS
Devex	NA
Turbine Supply	A few successful tier 3 suppliers
Turbine Installation	Moderate (NB. A 2016 report)
Foundation Supply	
Fixed Foundation Installation	Moderate (NB. A 2016 report)
Floating Moorings Supply	NA
Floating Marine Operations	Linked to Hywind
Array Cable	
Export Cable	
OSS/OnSS Electrical & Civil	Engineering rather than fabrication
OSS Foundation	Engineering rather than fabrication
Other Capex	NA
Opex	Strong in the SOV market
Abex	NA

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

<table>
<tr><th>STYRINGSKOMITEEN FOR GRØNNE ELEKTRISKE VERDIKJEDER (2020)
Styringskomiteen for Grønne Elektriske Verdikjeder</th><th>SEGMENT</th><th>COMMENTS</th></tr>
<tr><td rowspan="14">GRØNNE ELEKTRISKE VERDIKJEDER (INCLUDES OFFSHORE WIND CHAPTER).

Targets:
2020-2025. Norwegian industry provides services to 5% of the bottom fixed European market and a considerably higher market share within floating wind.
2025-2030. The Norwegian offshore wind supply chain turnover is 9 billion EUR per year, which relates to 10% of the global market.
2030-2040. The Norwegian supply chain has maintained 10% market share and is leading within segments of the value chain.
The report suggests focus areas and actions to be included in a long-term offshore wind strategy.</td><td>Devex</td><td>Strong on project development and management.</td></tr>
<tr><td>Turbine Supply</td><td></td></tr>
<tr><td>Turbine Installation</td><td>NA</td></tr>
<tr><td>Foundation Supply</td><td>NA</td></tr>
<tr><td>Fixed Foundation Installation</td><td>NA</td></tr>
<tr><td>Floating Moorings Supply</td><td>NA</td></tr>
<tr><td>Floating Marine Operations</td><td>NA</td></tr>
<tr><td>Array Cable</td><td></td></tr>
<tr><td>Export Cable</td><td></td></tr>
<tr><td>OSS/OnSS Electrical & Civil</td><td>NA</td></tr>
<tr><td>OSS Foundation</td><td>NA</td></tr>
<tr><td>Other Capex</td><td>Focusing on development of strong EPCI contractors for the international market.</td></tr>
<tr><td>Opex</td><td>With high-tech solutions</td></tr>
<tr><td>Abex</td><td>NA</td></tr>
</table>

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

BVG ASSOCIATES (2019)

OPPORTUNITIES IN OFFSHORE WIND FOR THE NORWEGIAN SUPPLY CHAIN

Main conclusions:

- New entrants from oil and gas manufacturers focusing on the capital-intensive phase should target multiple projects and seek out framework opportunities.
- Operational spending on offshore wind farms offers suppliers certainty of long-term demand, and customers are keen to use local companies to create a sustainable supply chain.
- Suppliers need to offer prospective customers cost competitive or innovative solutions to displace the existing supply chain.
- Norwegian suppliers must be aware of the differences within the sector and plan a market entry strategy accordingly.

SEGMENT	COMMENTS
Devex	Engineering, consulting and project management
Turbine Supply	A few successful tier 3 suppliers
Turbine Installation	
Foundation Supply	
Fixed Foundation Installation	
Floating Moorings Supply	Similar as for O&G, but need cost reduction
Floating Marine Operations	
Array Cable	
Export Cable	
OSS/OnSS Electrical & Civil	Electrical systems and components
OSS Foundation	
Other Capex	Engineering, consulting and project management
Opex	Synergies with O&G
Abex	Synergies with other Norwegian sectors

10 APPENDIX IV – RCG GRIP DATABASE

Data gathered as part of GRIP informs RCG's comprehensive offshore wind forecast model. The model calculates prospective dates for each stage of project development, as well as updates on contract milestones for major components on each individual project. RCG then extrapolates the data to generate forecasts for project capacity by market, by region and globally, as well as supply chain order book forecasts for both component contracting and installation rate. Where projects are yet to disclose a turbine rating or specific design, the GRIP model estimates an expected turbine nominal capacity based on the projected timeline for that specific site. The model analyses historic trends in the market to predict likely turbine ratings for future projects, accounting for the possibility of systems beyond the size of those contracted today, such as 15-20 MW units.

It should be noted that as RCG's GRIP forecast provides information on a project-by-project basis, any offshore wind and supply chain capacity is a representation of authenticated projects that have been announced. The model does not account for the emergence of new project sites and new offshore wind markets as there are no reliable milestones from which the model can generate an accurate forecast. Projects announced by governments due to be leased to developers are included in the GRIP system where there are clear site parameters and the leasing process for the site has been confirmed by official government sources. National or regional targets for offshore wind installation are not accounted for in the forecast, however, as offshore wind project site specific information is required.

RCG also applies its proprietary LCoE model to the GRIP database to generate live cost estimates and forecasts for each project and supply chain package by component. The LCoE model analyses over 250 parameters on each offshore wind project to calculate cost estimations for total expenditure (TotEx), development expenditure (Devex), capital expenditure (CapEx) and operational expenditure (OpEx). Supply chain costs are calculated at a package level and are based on historic contract trends and other factors that feed into the LCoE model, such as project site location and development timeline. Project-specific calculations for cost forecasting allow RCG to deliver reliable estimates for project and supply chain package costs on a market, regional and global scale.

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no

REFERENCES

American Wind Energy Association (2020). U.S. Offshore Wind Industry. Status Update – September 2020. Retrieved from https://www.awea.org/Awea/media/Resources/Fact%20Sheets/Offshore-Fact-Sheet.pdf

BVG Associates (2019). Global offshore wind market report, 2019

BVG Associates (2019), Opportunities in offshore wind for the Norwegian supply chain

BVG Associates (2020). Floating offshore wind: roadmap

Carbon Trust (2020), Floating Wind Joint Industry Project

Carbon Trust (2020). Floating Wind Joint Industry Project. Phase II Summary Report.

CenSES (2019), Conditions for growth in the Norwegian offshore wind industry

Department of Civil Engineering, University of Tokyo (2019). Upscaling and levelized cost of energy for offshore wind turbines supported by semi-submersible floating platforms. EERA DeepWind'19. Retrieved from https://www.sintef.no/globalassets/project/eera-deepwind-2019/presentations/e2_yukakikuchi20190117r.pdf

DNV GL (2020). Energy Transition Outlook 2020.

EIA (2019). International Energy Outlook 2019.

EIA (2020). Annual Energy Outlook 2020.

Energi 21 (2018), ENERGI 21, Strategy 2018

GWEC (2020). Global Offshore Wind Report 2020.

GreenTechMedia (2020). Chinese Manufacturers Could Rule the Offshore Wind Market Without Ever Leaving Home. Retrieved from: https://www.greentechmedia.com/articles/read/chinese-firms-could-dominate-offshore-wind-market-without-ever-leaving-home#gs.i7ybg2

IEA (2019). World Energy Outlook 2019.

IEA (2019). Offshore Wind Outlook 2019.

MAKE (2016), Norwegian opportunities in offshore wind

Menon (2019), Verdiskapingspotensialet knyttet til utviklingen av en norskbasert industri innen flytende havvind

Multiconsult (2019), Kartlegging av den norskbaserte fornybarnæringen.

NTNU, Havvind – en industriell mulighet

Styringskomiteen for grønne elektriske verdikjeder (2020), Grønne elektriske verdikjeder

THEMA, Multiconsult, future technology (2019), Hywind Tampen - Samfunnsmessige ringvirkninger

US Department of Energy (2019). 2018 Offshore Wind Technologies Market Report.

WindEurope (2018). Floating offshore wind - A policy blueprint for Europe.

World Bank Group (2020). World Bank Group Offshore Wind Development Programme. Retrieved from: http://pubdocs.worldbank.org/en/120581592321163692/WBG-Offshore-Wind-Program-Overview-Jun2020.pdf

THEMA Consulting Group
Øvre Vollgate 6, 0158 Oslo, Norway
www.thema.no