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# Norwegian supply chain opportunities in offshore wind

A report by  **BVG** associates

*In cooperation with:*

**EKSPORTKREDITT**  
Export Credit Norway

 Norges Rederiforbund  
Norwegian Shipowners' Association

 Norsk Industri

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*Front cover image courtesy of Fred. Olsen Windcarrier*



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Since the first installation 20 years ago, offshore wind has become a significant proportion of Europe's renewable energy mix and has attracted huge investment. The turbines have developed to become the largest rotating machines in the world and costs have reduced significantly. Supply chains have developed across Europe to support all elements of offshore wind from project development through to wind farm operations. As the industry develops these supply chains will evolve, learning from other industries in order to improve efficiency and lower costs.

Norway has a strong offshore supply chain from decades of supporting the maritime and oil and gas industries. BVG Associates was commissioned by Norwegian Energy Partners, supported by The Federation of Norwegian Industries, Norwegian Shipowners' Association and Export Credit Norway to undertake an assessment of the Norwegian supply chain in relation to the growing offshore wind market.

The offshore wind industry presents exciting new opportunities for Norwegian suppliers prepared to engage and work with the main players in the industry. This report is intended to be used by Norwegian authorities and companies considering a move into offshore wind in order that they can gain an appreciation of:

- The dynamics of the main European markets
- How offshore wind projects are contracted
- The offshore wind life cycle
- The opportunities for the Norwegian supply chain, and
- Strategies for market entry.

While individual company's offerings will always determine their opportunity, seven areas have been identified, based on the structure of the industry, that represent the greatest opportunities for the existing Norwegian offshore supply chain.

### *Project management*

Norwegian suppliers of consultancy and project management services are already active in offshore wind and there are good synergies with other maritime sectors. Norwegian suppliers are well placed to make a difference in this sub-element of the sector.

### *Subsea cables*

Major suppliers of subsea cables for offshore wind already have manufacturing facilities in Norway. Other Norwegian suppliers are well placed to develop associated components, such as connectors and terminations.

### *Offshore substation structures*

Synergies are strong with both shipbuilding and offshore oil and gas platforms. Norwegian supplier Aibel has developed a self-installing gravity base structure for foundations, and other Norwegian companies have won contracts in corrosion protection.

### *Turbine foundations*

Norwegian suppliers are already working to transfer learning from the oil and gas sector into this area of offshore wind. Norway's Statoil is currently installing the world's largest floating offshore wind farm in Scotland.

### *Installation equipment and support services*

This is a sector that offers a large number of contracts for a wide range of services. Synergies are strong with other marine operations in which Norwegian companies have good experience.

### *Maintenance and inspection services*

Synergies are very strong with the Norwegian offshore and maritime supply chain. There are many contracts available across a wide range of activities. Norwegian companies already provide services including cable monitoring and general subsea engineering

### *Vessels and equipment*

Many opportunities exist in this area for Norway's strong maritime supply chain. Norwegian suppliers are already at the forefront of the shift to service operation vessels for far from shore wind farms.

Figure 1 illustrates the activities that are undertaken in developing, building and operating an offshore wind farm and the greatest opportunities for the Norwegian supply chain are highlighted. Cross-cutting activities, although not categorised as a supply chain sub-element, are those activities that can be applied across multiple areas, such as general engineering support and consultancy.

Diversification into a new market can be rewarding for suppliers; it is, however, important to address some of the challenges they will face by:

- Spreading risk during the capital intensive construction phase by targeting multiple projects or framework agreements
- Using experience from other sectors to demonstrate experience suited to the long term operational phase
- Offering innovative, cost effective solutions to stand out in a competitive market, and
- Gaining awareness of the sector and demonstrating commitment.

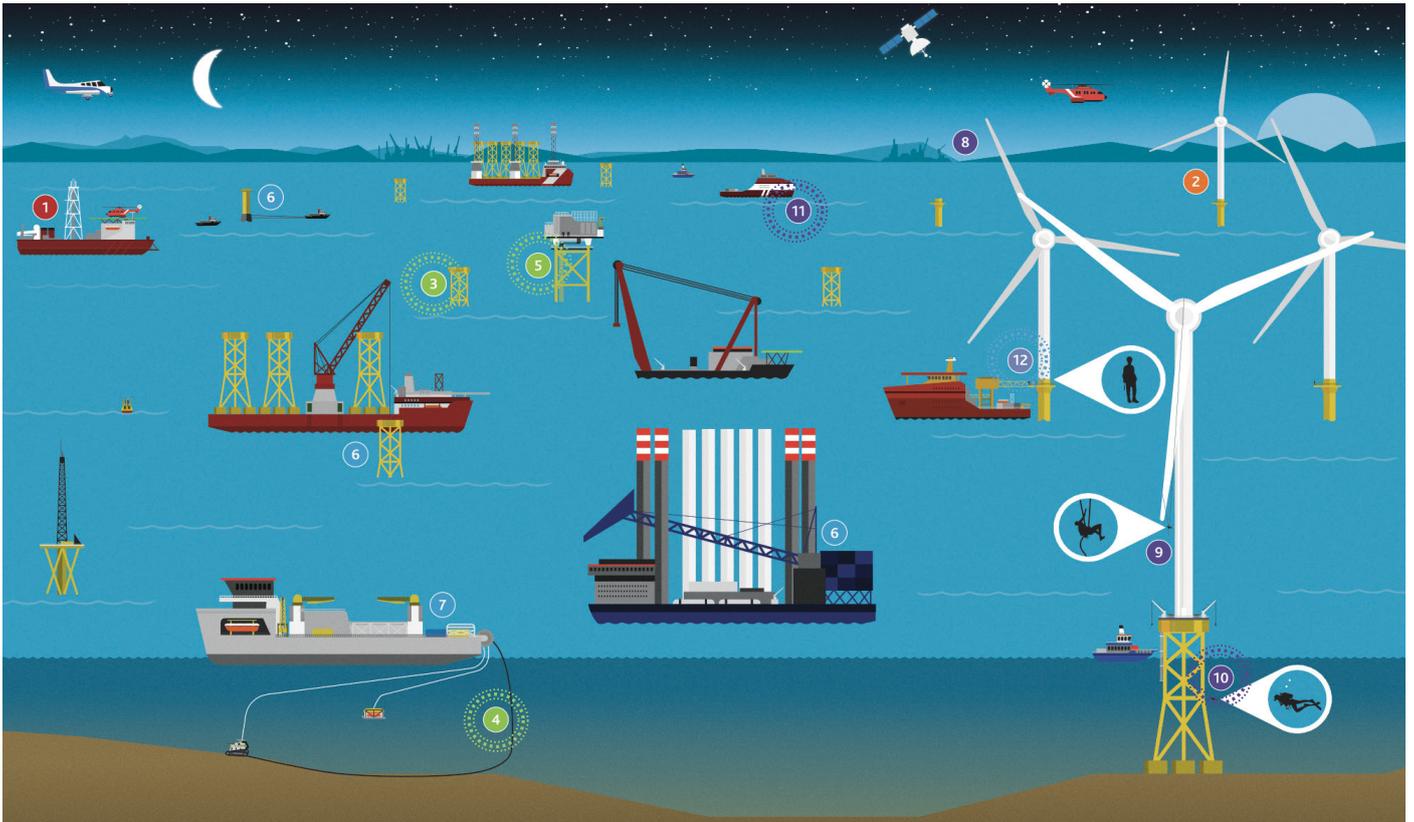


Figure 1 Illustration of the offshore wind supply chain (greatest opportunities for Norwegian supply highlighted with concentric rays).

| Development and project management |   | Turbine supply |   | Balance of plant |                   | Installation and commissioning |                                     | Operation, maintenance and service |                      |    |                                |
|------------------------------------|---|----------------|---|------------------|-------------------|--------------------------------|-------------------------------------|------------------------------------|----------------------|----|--------------------------------|
| 1                                  | Surveys, site investigations and development services | 2              | Turbine components manufacture and assembly | 3                | Foundation supply | 6                              | Turbine and foundation installation | 8                                  | Wind farm operations |    |                                |
|                                    |   |                |   | 4                | Cable supply      |                                |                                     | 7                                  | Cable installation   | 9  | Turbine maintenance            |
|                                    |   |                |   | 5                | Substation supply |                                |                                     |                                    |                      | 10 | Inspection and repair services |
|                                    |   |                |   |                  |                   |                                |                                     | 11                                 | Offshore logistics   |    |                                |
| 12 Cross cutting activities        |   |                |   |                  |                   |                                |                                     |                                    |                      |    |                                |

# 1. Foreword



The latest German tender for offshore wind saw two companies bid for a zero-subsidy offshore wind build out. While this is not expected to be the new normal quite yet, it is a major breakthrough for the industry.

In Europe, the clear leading global region for offshore wind development, the build out has accelerated in recent years to reach more than 13 GW installed capacity, or a total of roughly 58 billion GBP spent. Going forward, expectations are high and recognised strategy advisors and industry commentators are expecting offshore wind to be a major contributor to the energy mix in the future, not only in Europe but in a number of countries with exploitable offshore wind resources.

As described in our report from 2016, *Norwegian Opportunities in Offshore Wind*, the Norwegian industry has strong expertise in offshore environments and operations. It is supported by an excellent maritime industry; these factors combine to give a strong offering to the offshore wind industry. In some areas, the share of Norwegian companies active in the industry is already very high, such as in subsea cables, cable installation, substations and both substation and turbine installation services.

The recent reduction in activity in offshore oil and gas has allowed a number of Norwegian companies to find a new market supplying to offshore wind. This industry is highly innovative and a number of solutions, technologies and processes have already been implemented in the offshore wind market to allow for reduced cost and higher efficiencies.

This report seeks to give you a solid understanding of the Norwegian industry offering to offshore wind, while at the same time analysing the opportunities for the Norwegian industry in the offshore wind value chain.

We hope that the report will provide you with a valuable tool to identify new cost reducing technologies and services in offshore wind while at the same time give you a better understanding of the Norwegian industry's opportunities in this exciting market.

Many thanks to our partners, The Federation of Norwegian Industries, Norwegian Shipowners' Association and Export Credit Norway for supportive engagement and funding.



Jon Dugstad

Head of Wind & Solar

Norwegian Energy Partners

## 2. Introduction

Renewable energy sources made up 86% of new generating capacity added to Europe's electricity grids in 2016. Wind power has now become the second largest form of power generation in Europe; 10 years ago it was fifth. More than half of the investment in new renewable energy capacity in Europe in 2016 was for offshore wind, which highlights the importance placed on this technology and the opportunity it presents.

Over the last two decades offshore wind has grown to become a utility scale source of electricity generation. By the end of 2016 14.9GW of capacity had been installed globally. The majority of these wind farms are in Europe, with the North Sea in particular having an installed capacity of 8.9GW across more than 40 wind farms and a pipeline of more projects over the coming years.

About 3,600 offshore wind turbines and more than 60 offshore substations have been installed in Europe since the first offshore wind deployment in 1991. That project in Vindby, Denmark, used eleven 0.5MW turbines; by contrast London Array, the world's largest wind farm, has 175 3.6MW turbines. State of the art turbines have a nameplate generating capacity of 8MW with blades in excess of 80m long. A single rotation of an 8MW rotor can power a regular family home for more than 24hrs. Progress on the technology continues at pace with projects planned for 10MW turbines and roadmaps in place to get to 15MW.

Supply chains have developed to support not only the turbines but foundations, access, operations, maintenance, servicing, equipment and services. In spite of the great advances made over recent years a number of significant challenges remain, not least the difficulties in moving to deeper water for commercial scale projects. Innovations will be required in order to address these challenges; suppliers to parallel sectors are in a good position to transfer their experience and ensure that these challenges are resolved in a cost effective manner.

Since 1991, there has been €58 billion of capital and operational expenditure in the European offshore wind industry. Current market projections suggest that an additional €100 billion will be spent between 2017 and the end of 2025.

Norwegian Energy Partners is working to maximise the business opportunities in offshore wind for its partner companies. To support its activities it has partnered with The Federation of Norwegian Industries, Norwegian Shipowners' Association and Norwegian Export Credit and commissioned BVG Associates (BVGA) to produce a report that will provide practical guidance for companies with relevant skills and highlight the most attractive parts of the supply chain.

Norway has a globally competitive offshore and maritime industry and many companies have already been successful in offshore wind. The long-term challenges in the oil and gas industry mean that many companies will look to grow their offshore wind business, while others will wish to make their first steps in the industry. The major challenge for Norwegian companies is that Norway has no pipeline of offshore wind projects and their success is dependent on them succeeding in the export market.

This report will first provide an overview of the main European markets. This will help Norwegian suppliers to understand factors from governance and subsidies through to customers and competitors. The report also considers the different contracting models employed in the offshore wind sector, who uses them and why.

The bulk of the report reviews the strengths of the existing Norwegian supply chain and its synergies with offshore wind. Each element of the offshore wind supply chain was assessed according to defined criteria. This activity was informed by an analysis of 200 Norwegian companies and their capabilities in relation to the offshore wind sector. In the sub-elements identified as presenting the strongest opportunities for Norwegian suppliers, case studies have been provided which highlight existing Norwegian successes in the sector.

The report concludes with recommendations as to how companies can approach the market. It will discuss the characteristics and requirements of the sector, the barriers to entry and how to overcome them. As the Norwegian supply chain is changing rapidly, updates to the report will be published at need.

# 3. European market overview



BVGA has prepared two page summaries of key European markets, covering:

- Market size
- Regulation
- Key organisations
- Project owners, and
- Key suppliers.

Summaries of these different markets are presented for convenience in Table 1. The full summaries, including an overview of the European market as a whole, are in Appendix A.

These briefing documents provide market information and statistics and can be used by potential suppliers to the industry to help them approach the sector.

**Table 1 Summary of key markets.**

| Country        | Market growth  | Leasing and consent  | Subsidy   | Transmission system operator   | Developers   | Suppliers   |
|----------------|--|--|---|--|--|---|
| <b>BELGIUM</b> | The Belgian market is expected to grow from 0.8GW of installed capacity at the end of 2016 to 2.4GW by 2025. | Leases for offshore wind farms are awarded by the Belgian Government.  | A Contract for Difference (CfD) subsidy mechanism is used to support development. The strike price is currently €138/MWh. | Elia is the transmission system operator in Belgium and has historically shared the costs for connections to the grid. Elia is a publicly listed company on the Brussels stock exchange. It is currently consulting on the development of a Belgian offshore grid. | The largest project owner in Belgium is Otary which is a partnership of eight Belgian companies.   | A number of major suppliers to the industry are headquartered in Belgium. Examples include GeoSea, Scaldis, Jan De Nul, Smulders and Fabricom.    |
| <b>DENMARK</b> | The Danish market is expected to grow from 1.3GW of installed capacity at the end of 2016 to 3.0GW by 2025.  | Leases for offshore wind farms are awarded by the Danish Energy Agency, which is also responsible for issuing all required licences.   | A feed in tariff mechanism guarantees tendered prices for 50,000 generating hours for up to 20 years.                     | Energinet.dk designs and operates the offshore substation and export cable.  | The largest project owner in Denmark is currently DONG Energy. The existing pipeline of projects means that Vattenfall will take the lead in the coming years. | A number of major suppliers to the industry are headquartered in Denmark including MHI Vestas, Bladt Industries, A2SEA and Swire Blue Ocean.      |
| <b>FRANCE</b>  | There is currently no installed capacity in France; this is expected to grow to 2.7GW by 2025.               | Leases for offshore wind farms are awarded via a competitive tendering procedure. The Energy Ministry (DGEC) short-lists bidders which are then advised and assessed by the Energy Regulation Committee (CRE). | A feed in tariff mechanism guarantees an electricity price for 20 years   | RTE is a wholly owned subsidiary of EDF and is the transmission system operator in France. RTE builds and operates the transmission system.  | EDF and Enbridge own the largest proportion of the near term projects.   | A number of major suppliers to the industry are headquartered in France including GE/ Alstom, GE Grid Solutions, STX France Solutions and Nexans. |



| Country               | Market growth   | Leasing and consent   | Subsidy   | Transmission system operator   | Developers   | Suppl   |
|-----------------------|---|---|---|--|--|---|
| <b>GERMANY</b>        | The German market is expected to grow from 4.1GW of installed capacity at the end of 2016 to 10.0GW by 2025.  | Germany has recently introduced a new Offshore Wind Act (WindSeeG). This introduces a centralised planning approach.  | From 2021, CfDs will be awarded through competitive auctions; in the meantime a transitional mechanism is providing support to projects to be commissioned between 2021 and 2025. | Offshore grid connections are constructed, owned and operated by two transmission system operators; TenneT (North Sea) and 50Hz (Baltic).          | The largest project owners in Germany are DONG Energy and EnBW which both have operating projects and a number of near term developments.  | A number of major suppliers to the industry are headquartered in Germany including Siemens, Senvion, NKT Cables and Siem Offshore Contractors.  |
| <b>NETHERLANDS</b>    | There is currently 1.1GW of installed capacity in the Netherlands; this is expected to grow to 4.7GW by 2025. | Leases for offshore wind farms are awarded via a competitive tendering procedure by the Ministry of Economic Affairs.   | Successful projects receive a CfD for 15 years and a 30 year operating licence.   | TenneT is the transmission system operator and has developed plans to link all projects through an offshore link.                                  | DONG Energy has the largest portfolio of near term projects although it has yet to develop any projects in Dutch waters. Major oil and gas company Shell has shares in Dutch projects and is making a growing commitment to offshore wind. | A number of major suppliers to the industry are headquartered in the Netherlands including Boskalis, Van Oord and Sif.  |
| <b>UNITED KINGDOM</b> | There is currently 5.3GW of installed capacity in the UK; this is expected to grow to 17.0GW by 2025.         | Leases for offshore wind farms are awarded by The Crown Estate. Consent is granted by Government ministers after examination by the Planning Inspectorate or Marine Scotland. | Subsidies are provided via a CfD which lasts for 15 years.  | Offshore Transmission Owners (OFTOs) are granted licences to own and operate offshore transmission assets through a competitive tendering process. | DONG Energy has the largest portfolio of projects.   | In spite of the UK's position as the leading offshore wind market it relies heavily on overseas contractors to fulfil many contracts. Leading installer MPI Offshore and leading cable supplier JDR Cables are both UK based. |

# 4. Procurement strategies

Offshore wind developers generally adopt either a multi-contracting strategy or an engineer, procure, construct, install (EPCI) strategy.

## 4.1. Multi-contract strategy

Under a multi-contracting strategy, the developer typically awards about nine main contracts covering the key elements of the wind farm, shown in Figure 2. Some packages can be split or combined depending on developer needs and capabilities and the value being offered by suppliers.

Multi-contracting is often preferred by large utilities, particularly if the project is funded from their balance sheet.

DONG, E.ON, Scottish Power, Statoil, Vattenfall and wpd typically favour this approach.

The ownership and construction of the grid connection (substation and export cables) varies between countries as described in Section 3. In the UK, for example, the Offshore Transmission Owners (OFTOs) are selected via a competitive tender process and granted licences to own and operate the assets. In many cases the developers have taken up an option to build the transmission assets and then sell them to the OFTO within 18 months of commissioning. In the Netherlands and Belgium, Transmission Systems Operators have been assigned centrally and plan to link all projects via an offshore link, rather than connecting wind farms on a project by project basis.

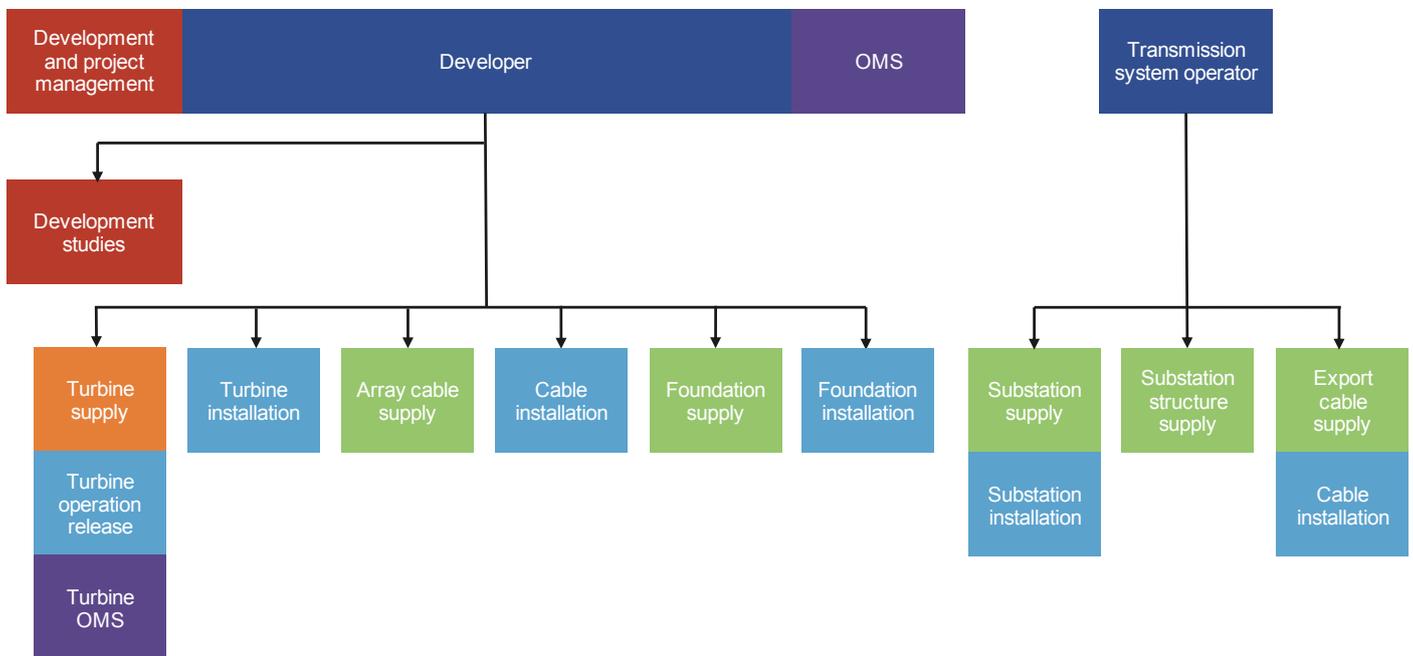


Figure 2 Typical multi-contracting structure for offshore wind.



## 4.2. EPCI strategy

EPCI contracting usually involves three main packages as shown in Figure 3. The turbine package is typically kept separate as this is a critical one for the wind farm design and therefore needs to be specified before the remaining contracts can be finalised. The other two packages vary in scope according to the strengths of the bidders. As described above, the transmission assets package is treated differently depending on the jurisdiction in which the project is deployed. The contract value can exceed €1 billion which is a major commercial exposure for all but the largest and most experienced contractors.

Independent developers, such as Meerwind, Otary and Trianel, and less experienced utilities, such as EDPR and SSE prefer this approach.

For example, at SSE's Beatrice project, Siemens was awarded the turbine contract while Seaway Heavy Lifting has the EPCI contract for the balance of plant which included awarding contracts for foundation manufacturing to Smulders, Bladt and BiFab. This approach allows SSE to manage a small number of contractors and reduce its risk.

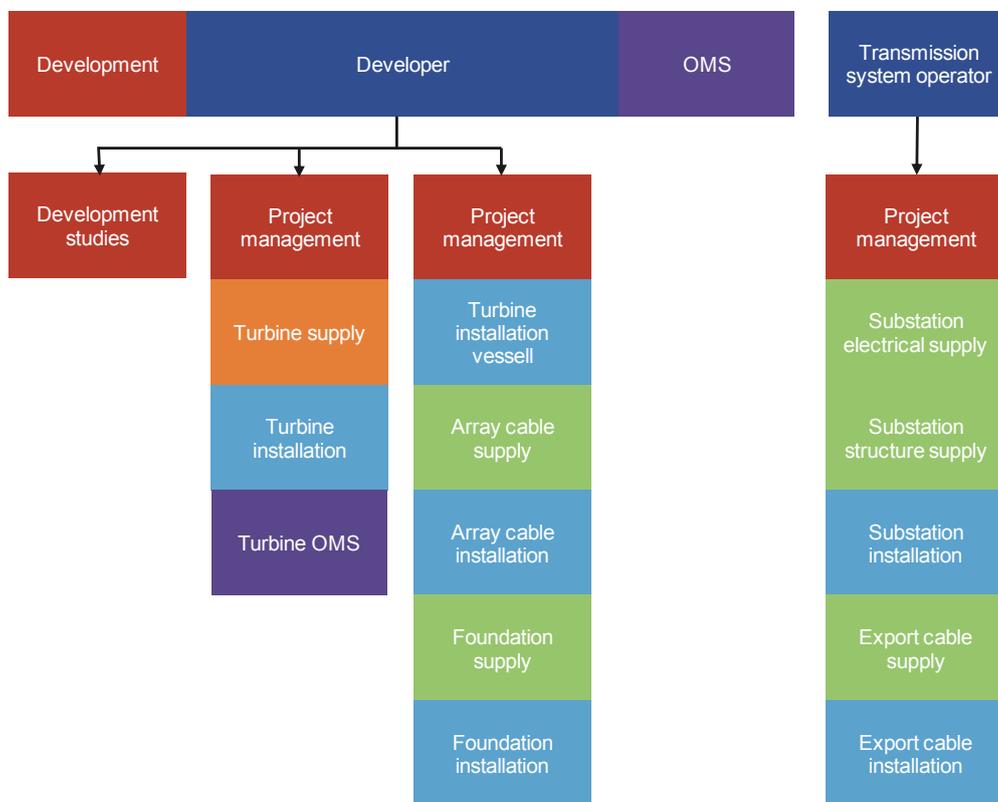
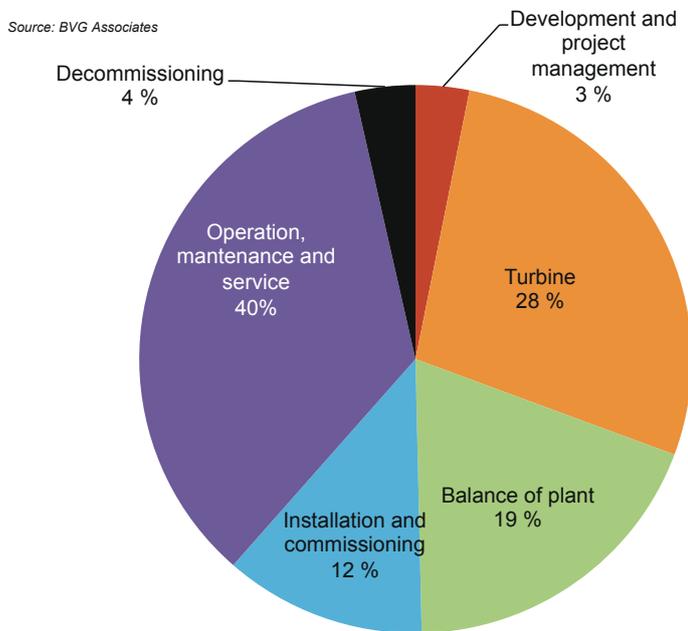


Figure 3 Typical EPCI structure for offshore wind.

# 5. Methodology

The offshore wind supply chain can be categorised by six supply chain areas. A breakdown of the percentage contribution from each area to the life-time project cost is shown in Figure 4.



**Figure 4 Cost breakdown (undiscounted) of an offshore wind farm reaching final investment decision in 2020. The costs include transmission.**

These areas have been split into 29 sub-elements, which will be discussed in section 6. In order to identify the opportunities most accessible to Norwegian companies, these were screened using six criteria:

- Track record of Norwegian companies in the offshore wind market
- Synergies between offshore wind and the Norwegian supply chain, considering how well parallel sectors match the requirements of the offshore wind sector (this includes companies with the potential to enter offshore wind but have not yet done so)
- Appetite from offshore wind, considering how much demand there is for Norwegian expertise in offshore wind; this considers the major challenges faced by the offshore wind industry and whether they are likely to welcome solutions from other offshore sectors

- Potential for levelised cost of energy (LCOE) benefit from new involvement by Norwegian companies, considering to what extent their products or services have a new application in offshore wind
- Size and timing of investments by Norwegian companies, considering to what extent this represents a barrier to entry, and
- Size of the opportunity, what it is potentially worth in relative terms.

Company data held by Norwegian Energy Partners, its partners and BVGA was considered to identify relevant areas of company expertise and experience of offshore wind.

We categorised 200 organisations with a presence in Norway. This is not an exhaustive list and other companies are likely to be in a position to supply the offshore wind industry; we do however believe that 200 companies is a large enough sample to represent the Norwegian supply chain.

The companies were categorised in a number of ways:

- Are they an existing supplier? Are they actively pursuing opportunities? Do they have the capability but haven't explored the sector?
- What level of service can they provide?
- Which of the six supply chain areas do they or can they service?
- Which of the 29 sub-elements do they or can they service?

This categorisation, coupled with BVGA's knowledge of the sector, allowed us to score the opportunity in each of the sub-elements. A score of one to four was used with one being the weakest score and four being the strongest. An overall red, amber or green score was then assigned to the sub-element based on the score across the criteria, with green the most favourable. Areas of supply denoted as amber or red are still an opportunity for Norwegian companies; the assessment simply considers where the logical argument exists for the best chance of diversification success.

# 6. Norwegian supply chain assessment



## 6.1. Overview of data analysed

The list of companies considered was provided by Norwegian Energy Partners, The Federation of Norwegian Industries, Norwegian Shipowners' Association and Norwegian Export Credit based on their own partner lists and attendees at events. Of the 200 companies considered, 50% were considered to be existing suppliers to the offshore wind industry (see Figure 5).

Source: BVG Associates

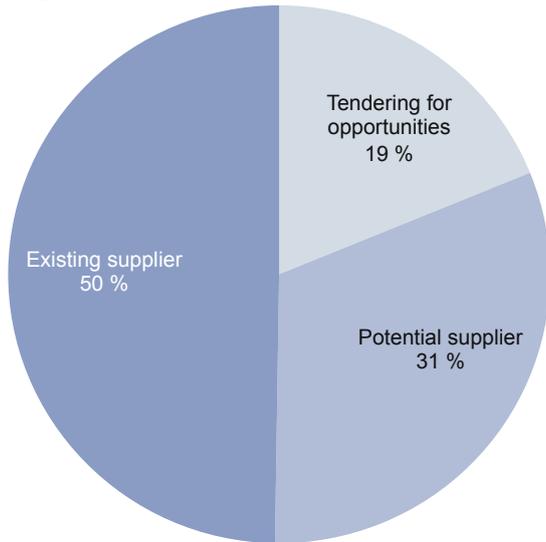


Figure 5 Status of Norwegian suppliers.

Operations, maintenance and service (OMS) is the supply chain area with the most companies in a position to provide support followed by development and project management (see Figure 6). The number of vessels required in the operational phase of a commercial wind farm is well aligned with Norway's capability.

Source: BVG Associates

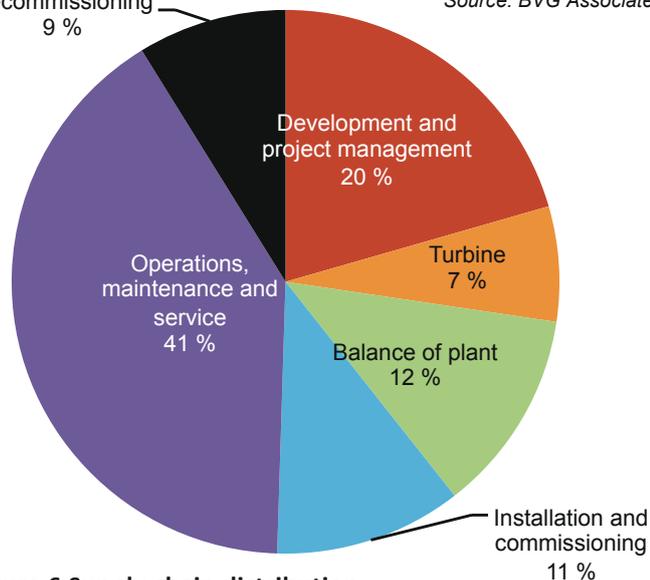


Figure 6 Supply chain distribution of Norwegian suppliers.

The split by type of support required by the sector shows that the bulk of companies considered are service providers (see Figure 7). It is not surprising that main contractors and main component suppliers make up such a small proportion as the number of main contracts is generally limited. It should be noted that companies often contribute to multiple supply chain areas; vessel operators for example will often support installation as well as OMS.

Source: BVG Associates

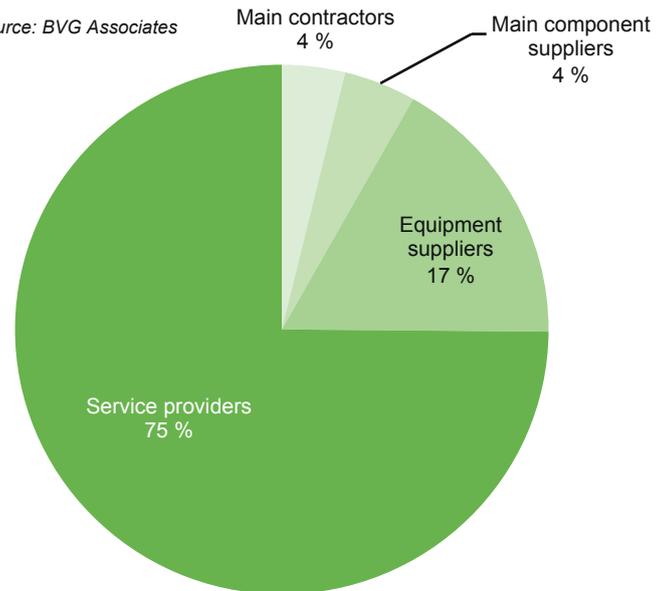


Figure 7 Type of support provided.

More detail on the supply chain capabilities is presented as a value chain matrix in Appendix C, along with a categorised list of companies.

## 6.2. Development and project management

Development and project management makes up only 3.2% of lifetime expenditure as shown in Table 2.

Opportunities exist for companies working in the offshore supply chain but the lifetime spend is relatively small.

No two offshore wind farms are the same and specialists are therefore needed across all stages of the development process. Developers often subcontract the project management and coordination of specialist tasks and services throughout the process.

During site selection, contractors carry out site investigations including geotechnical and geophysical studies to identify suitable locations for the wind farm and cable routes. These investigations identify sea bed topography and locate unexploded ordnance. Further geophysical surveys are often completed post-consent and pre-construction to determine turbines locations, foundation design and cable routes.

Environmental studies such as wildlife impact assessments make up the smallest proportion of this area and are often combined with the geophysical surveys. Initial surveys are completed during development but there are also post-construction monitoring activities. Vessels for wildlife surveys do not have a demanding specification and are often shared with other sectors.

In general, the following support services would normally be required: surveys, legal, planning, management of consent applications, financial due diligence, stakeholder engagement, geological and economic assessments.

Figure 8 shows the cost breakdown of the development and project management sub-element.

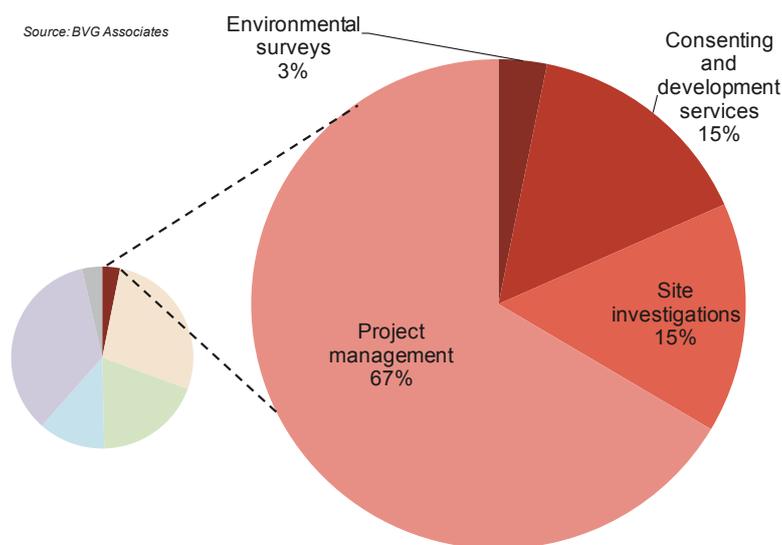


Figure 8 Breakdown of costs of development and project management.



**Table 2 Summary of development and project management opportunity.**

| Sub-element                                | Lifetime spend for a 1GW wind farm |                  | Norwegian opportunity |
|--|------------------------------------|------------------|-----------------------|
| <b>ENVIRONMENTAL SURVEYS</b>               | 0.1%                               | 60 kr million    |                       |
| <b>CONSENTING AND DEVELOPMENT SERVICES</b> | 0.5%                               | 260 kr million   |                       |
| <b>SITE INVESTIGATIONS</b>                 | 0.5%                               | 260 kr million   |                       |
| <b>PROJECT MANAGEMENT</b>                  | 2.1%                               | 1,160 kr million |                       |

## Environmental surveys

Environmental surveys establish the distribution, density, diversity and number of different species, and cover the following activities:

- Benthic environmental surveys
- Pelagic environmental surveys
- Bird environmental surveys, and
- Marine mammal environmental surveys.

Contractors often undertake benthic and pelagic studies together using local vessels. Bird surveys are typically undertaken by a mix of boat and aeroplane observations. Marine mammal observers are used to assess the acoustic impacts during offshore activities such as piling. These studies occur early in the development process to inform the environmental impact assessment (EIA).

Current suppliers include Niras, IMARES, Fugro EMU, MMT, Gardline and Hi Def.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Norway only has a small demonstration offshore wind turbine in operation and no near-term pipeline of projects. There has therefore been no requirement to support what is a predominantly local activity.
- Some survey techniques can be transferred from other offshore sectors where Norway has strengths, however some elements of this are wind specific, such as bird studies
- The offshore wind environmental survey industry is mature and competitive with no significant demand for new entrants
- Developments in the understanding of cumulative impacts of multiple wind farms on wildlife could significantly lower the risk of project development
- New entrants need to make minimal investment specific to offshore wind
- The size of the opportunity is small.

*We have concluded that the opportunity for the Norwegian supply chain to provide environmental services is low because overall there is not the required depth of experience and there is little logic in pursuing a low value export opportunity.*

The assessments are summarised in Figure 9.

### Box 1 Norwegian supply chain expertise

Norway's experience in the development and project management value chain mostly lies in its project management capabilities and site investigation support services. This area of the supply chain does not involve major components or use many large contractors.

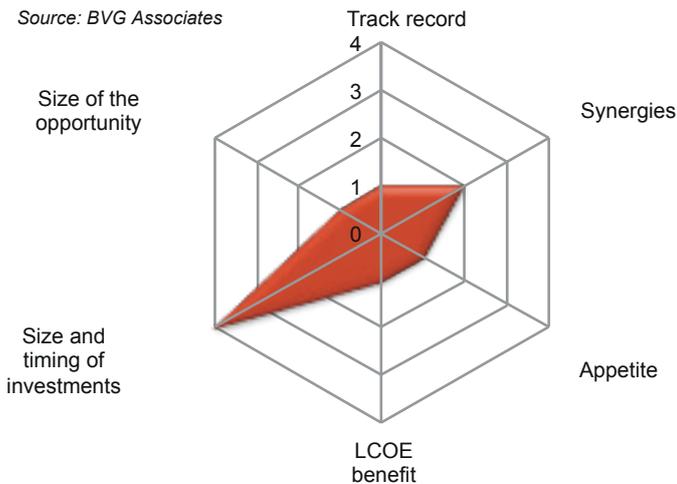
#### Equipment suppliers

There are a number of Norwegian instrumentation providers which are capable of supplying to this sector. For example, Fugro Oceanor provides metocean buoys and sensors, and Automasjon og Data provide metmast instrumentation packages.

#### Service providers

A wide range of services are already provided by Norwegian suppliers to the development and project management area. These include consultancy, legal and financial services, training, surveying and engineering support. Examples include iSurvey which undertakes sea bed surveys, Semar which plans marine operations and StormGeo which provides weather forecasting services.

Source: BVG Associates



**Figure 9 Summary of the assessment for environmental surveys.**

## Consenting and development services

Consenting and development services is a sub-element that requires a detailed knowledge of planning, consenting and legal issues in the jurisdiction of the wind farm. Developers face a wide range of obstacles in securing planning consent for offshore wind. Impacts on tourism, wildlife, fishing, visual impact and aviation are among the considerations.

Current suppliers are typically specialised firms in the country whose waters the wind farm is installed.

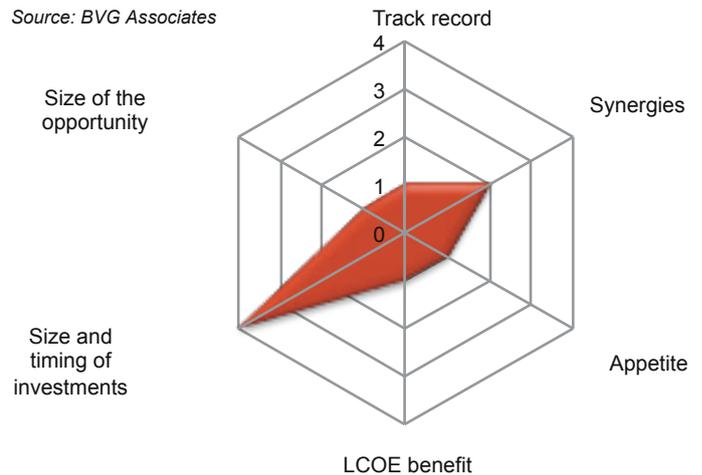
Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Norway only has a small demonstration offshore wind turbine in operation and no near-term pipeline of projects. There has therefore been no requirement to support what is a predominantly localised activity.
- Some of the offshore consenting activities overlap with other offshore sectors where Norway has strengths
- This sub-element is mature and competitive with no significant demand for new entrants
- This is a relatively small part of the supply chain which has limited impact on LCOE
- Minimal investment specific to offshore wind is required by new entrants
- The size of the opportunity is small.

*We have concluded that the opportunity for the Norwegian supply chain to provide development and consenting services is low because overall there is not the required depth of experience and logic suggests that these services are best provided by local suppliers.*

The assessments are summarised in Figure 10.

Source: BVG Associates



**Figure 10 Summary of the assessment for consenting and development services.**

## Site investigations

Site investigations are required at both the wind farm location and at the proposed onshore and offshore cable route and the onshore substation site. Geophysical surveys include bathymetric, cable route and unexploded ordnance surveys. These surveys plot the surface topography in support of the wind farm design and installation engineering. Geotechnical investigations are the most costly part of the survey work and are made at the proposed turbine locations using cone penetration tests and core sampling.

Current suppliers include Fugro, Gardline, Geo, MMT, Mainprize Offshore and Latitude Surveys.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- A small number of Norwegian companies already provide services and equipment. This includes instrumentation suppliers such as Nortek, remotely operated vehicles (ROV) suppliers such as Argus Remote Systems and consultancies like Sweco. Fugro is a leading supplier and draws significantly on its Norwegian labour force.
- Synergies are good as survey vessels have applications in a number of sectors. The most relevant parallel sector is oil and gas.



- The market is dominated by large players which price aggressively to secure work. This may reduce the appetite for new suppliers. This sub-element is seasonal with opportunities for supply greater in the summer when vessels are in high demand.
- Investigation techniques are well established so opportunities for LCOE reduction are limited
- New entrants need to make minimal investment specific to offshore wind
- The size of the opportunity is small.

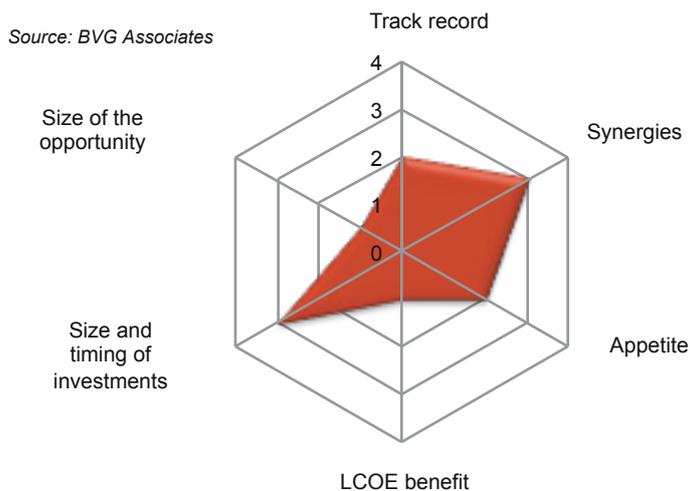
Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Norwegian companies have provided project management services to the sector although this is somewhat limited
- Synergies are good with other maritime sectors. The skills developed by working in the marine environment in terms of planning, risk, health and safety and others are transferrable.
- Developers are aware of the capability that is offered by suppliers to other maritime industries. Norway is particularly well placed to provide services specifically related to offshore activities.
- Developers are keen to reduce the lead time of projects and reduce risk; effective project management is therefore a vital component which can impact on the cost of capital and hence LCOE
- New entrants need to make minimal investment specific to offshore wind
- The size of the opportunity is moderate.

*We have concluded that the opportunity for the Norwegian supply chain to supply site investigation services is good because overall there is a reasonable level of experience offering a wide range of services and there are synergies with the existing offshore supply chain.*

*We have concluded that project management presents a major opportunity for the Norwegian supply chain because overall the synergies are very strong with existing activities, there is already good experience in Norway and there is the potential for Norwegian suppliers to make a difference.*

The assessments are summarised in Figure 11.



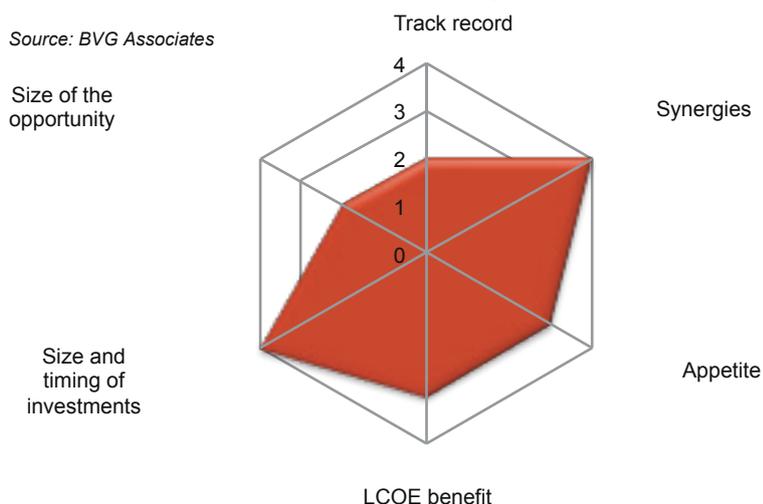
**Figure 11 Summary of the assessment for site investigations.**

## Project management

A wide range of consultancy and project management services are contracted by the developer during the development of the offshore wind farm. Often the developer prefers to contract with suppliers that can provide consultancy and project management services across several areas. Support includes legal advice, financial advice, engineering consultancy, risk management and logistics.

Current suppliers include companies such as DLA Piper, DNV-GL, ODE and RES.

The assessments are summarised in Figure 12.



**Figure 12 Summary of the assessment for project management.**

## Box 2: Project management

**Company:** StormGeo

**Sub-element:** Project management

### **Company background:**

StormGeo AS is a global provider of meteorological services and advanced analytics. The company was founded in 1997 in Bergen in Norway and has been active in the oil and gas sector since inception, providing weather forecasting services for most operators in the North Sea and Barents Sea area. From 2008 and onwards, StormGeo has been expanding fast, mainly through acquisitions, and now has about 350 employees in 22 countries around the world.

The main areas of activity are shipping and offshore oil and gas, where the company provides weather forecasting and routing services for thousands of vessels and offshore installations every day.

### **Task:**

The offshore wind industry is dependent on good and detailed weather forecasting services. Thus, it was an obvious move for StormGeo to enter into offshore wind, and the company has now serviced more than 60 offshore wind projects from 2009 and onwards. This includes pilot projects in the Taiwan Strait, where the company has also been providing typhoon forecasting.

### **Action:**

StormGeo was able to start servicing the first offshore wind clients without any significant investments. Along the way, the company has invested in improved weather and wave models, new weather forecasting services, a sales office in Hamburg, and training of personnel. StormGeo is present at all major offshore wind fairs and exhibitions.

### **Outcome:**

StormGeo's first offshore wind assignment was supporting the construction of the Thanet offshore wind farm in the Thames Estuary in 2009 (client: Vattenfall). Soon followed more projects in UK, German, Dutch and Scandinavian waters. Today, the company is probably the most experienced provider of weather forecasting for offshore wind.

Offshore wind presents some special challenges due to the sensitivity of the vessels and constructions (low working limits), combined with the fact that many projects are situated quite close to shore, where wave forecasting, in particular, can be challenging. The company has managed these challenges well.

StormGeo has found the market to be competitive, which has helped keep the team focused.

The main risk has been the rapidly falling prices, probably as a result of reduced activity in the oil and gas sector. The company has responded to this challenge by streamlining products and processes, thus bringing down cost.





### 6.3. Turbine supply

Turbine supply makes up about 28% of the lifetime spend of an offshore wind farm, as shown in Table 3. It is the single biggest contract placed by the developer.

The role of a wind turbine manufacturer is mainly one of a systems integrator, using components that are mainly externally sourced. Even where it manufactures components in-house, it will often have a second source of supply.

Turbine supply includes electrical and mechanical components and systems that make up a wind turbine nacelle, rotor and tower.

The nacelle components include the bedplate, drive-train, power take-off, control system, yaw system, yaw bearing, auxiliary systems, frame and cover, fasteners and conditioning monitoring system.

The rotor components include the blades, hub casting, blade bearings, blade pitch system, spinner (hub cover), auxiliary systems, fabricated steel components and fasteners.

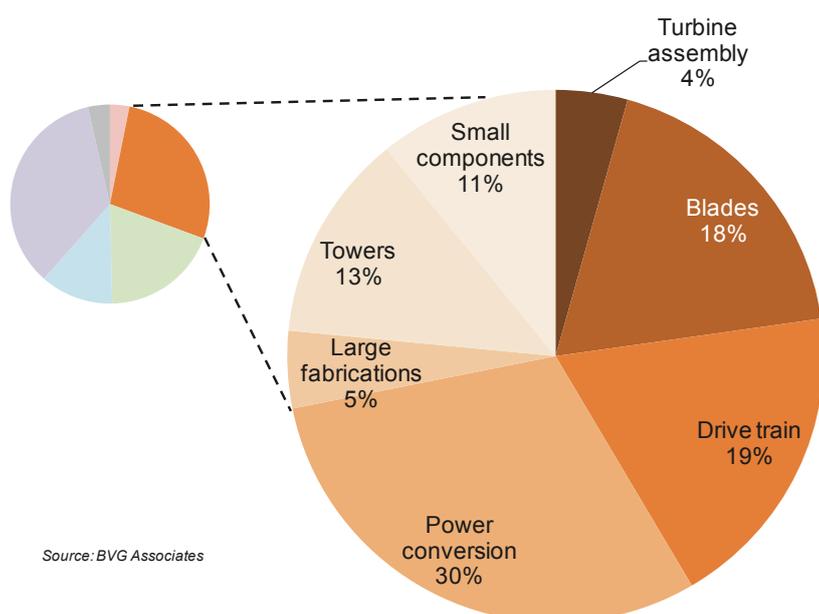
The tower components include steel plate, personnel access and survival equipment, electrical system including switchgear, tower internal lighting and fasteners.

No part of the turbine supply presents a strong opportunity for Norwegian companies. Specific opportunities do exist, particularly further down the supply chain, but they face a number of challenges in terms of competing with experienced suppliers in well-established markets.

Figure 13 shows the cost breakdown of the turbine supply sub-element.

**Table 3 Summary of turbine supply opportunity.**

| Sub-element               | Lifetime spend for a 1GW wind farm |                  | Norwegian opportunity |
|---------------------------|------------------------------------|------------------|-----------------------|
| <b>TURBINE ASSEMBLY</b>   | 1.2%                               | 660 kr million   |                       |
| <b>BLADES</b>             | 5.1%                               | 2,810 kr million |                       |
| <b>DRIVE TRAIN</b>        | 5.2%                               | 2,860 kr million |                       |
| <b>POWER CONVERSION</b>   | 8.3%                               | 4,630 kr million |                       |
| <b>LARGE FABRICATIONS</b> | 1.3%                               | 710 kr million   |                       |
| <b>TOWERS</b>             | 3.5%                               | 1,930 kr million |                       |
| <b>SMALL COMPONENTS</b>   | 3.0%                               | 1,650 kr million |                       |



Source: BVG Associates

**Figure 13 Breakdown of turbine supply sub-element.**

### Box 3 Norwegian supply chain expertise

Norway is lacking in expertise when it comes to turbine supply. There has, however, been some involvement.

#### Main component suppliers

ABB is a key supplier of electrical systems and provides small electrical components to both the onshore and offshore wind industry from a Norwegian manufacturing base. Norwegian technology developer Norsetek is developing a lightweight wind turbine for the onshore market, however only a small demonstration unit has been built.

#### Equipment suppliers

Norwegian companies are active in supplying ancillary equipment. Baggerød has provided doors and windows while Glamox has provided lighting. Devold AMT and 3B-Fibreglass have provided fibreglass textiles for blades and Vestas owned Dokka Fasteners has provided bolts and fastening equipment.

#### Service providers

Fedem Technology has successfully provided finite element modelling software designed for wind turbines.

## Turbine assembly

A wind turbine manufacturer will have a facility near a suitable port to assemble the final product from large subcomponents that are mostly externally sourced.

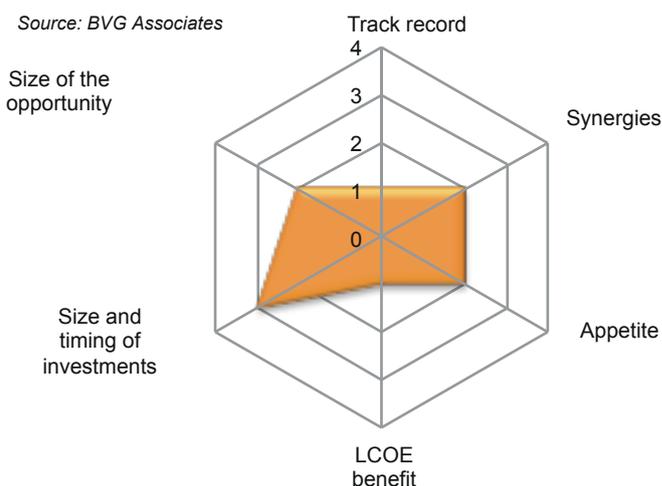
Current suppliers include GE, MHI Vestas, Senvion, and Siemens.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Norwegian companies have not been directly involved in this sub-element. Fred. Olsen group and NSG Wind have however invested internationally in companies that support this sub-element.
- Synergies are moderate given Norway's limited experience in assembling large structures in volume for example in automotive or aerospace
- Turbine manufacturers typically have a single turbine assembly facility to serve the whole European market located near its geographic centre. Given the lack of Norwegian projects there is little appetite to invest in such a facility in Norway.
- There is little opportunity for LCOE improvements from the involvement from Norwegian companies
- Norway's strong infrastructure in support of maritime industries means that only moderate investments would be required
- The size of the opportunity is moderate.

*We have concluded that the opportunity for the Norwegian supply chain to enter the turbine supply and assembly market is low because overall there is not the required depth of experience and assembly sites are likely to be based in countries with larger offshore wind markets.*

The assessments are summarised in Figure 14.



**Figure 14 Summary of the assessment for turbine assembly.**

## Blade manufacture

Most blades are made in-house by the wind turbine manufacturers. LM Wind Power is the leading external supplier, which was acquired by GE in 2016.

Suppliers continue to use fibreglass as a structural element. Carbon fibre is also used to reduce weight.

Current suppliers include the wind turbine manufacturers GE, MHI Vestas, Senvion, and Siemens-Gamesa, as well as LM Wind Power.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- There have been areas of success for Norwegian suppliers but the spend in relative terms is low. Devold AMT delivered fibreglass reinforcements in 2016 for LM Wind Power's 88m blade, which is the largest offshore wind blade in the world. Similarly, 3B's product has been used as a raw material on as many of 30% of blades manufactured to date.
- Synergies are few with other offshore and maritime industries
- Capacity elsewhere is sufficient to meet demand meaning there is little appetite for new suppliers



- An absence of Norwegian based suppliers companies with process and material innovations which could lead to improved reliability and lower LCOE needed for the larger blades
- Significant investment in quayside manufacturing facilities is required for new entrants
- The size of the opportunity is high because blades make up a significant proportion of turbine cost.

- New drivetrain technologies are already under development with a view to improving reliability and easing maintenance for next generation turbines
- Investments are likely to be associated with new turbine assembly facilities
- The size of the opportunity is high given the lifetime spend in this area.

*We have concluded that the opportunity for the Norwegian supply chain to enter the blade manufacturing sector is weak because overall the limited track record and low logic of supply makes success very difficult.*

*We have concluded that the opportunity for the Norwegian supply chain to enter the drivetrain market is weak because overall there isn't the required depth of experience and appetite for new suppliers.*

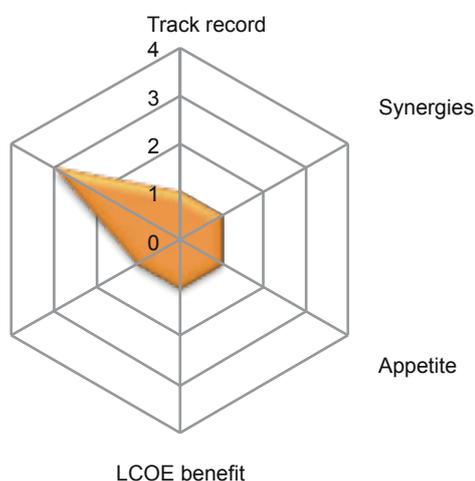
The assessments are summarised in Figure 15.

The assessments are summarised in Figure 16.

Source: BVG Associates

Size of the opportunity

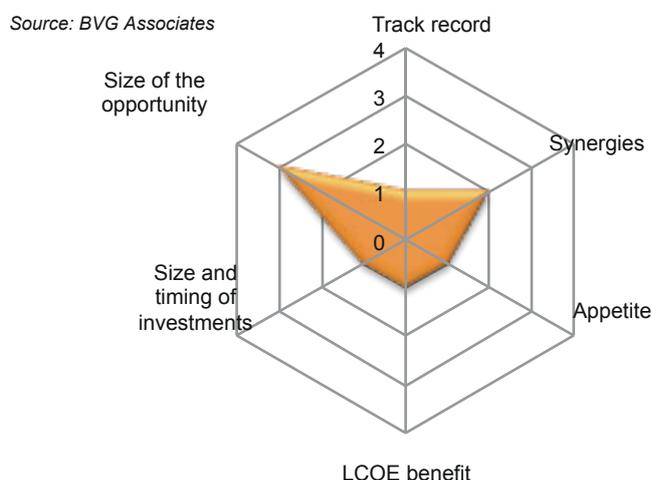
Size and timing of investments



Source: BVG Associates

Size of the opportunity

Size and timing of investments



**Figure 15 Summary of the assessment for blade manufacture.**

**Figure 16 Summary of the assessment for drivetrain manufacture.**

## Drivetrain manufacture

The major non-generator related components in a drivetrain are the main bearings and gearboxes. Most offshore wind turbines have either mid-speed or direct drive drivetrains. This reduces the number of components and has the potential to improve reliability.

Current suppliers for bearings include SKF, Timken, Rothe Erde, Schaeffler and NSK. For gearboxes; ZF, Winergy, Moventas and GE are the key suppliers.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- We have identified no supply from Norwegian companies
- Synergies exist in areas of the maritime industries where drivetrains are used such as in large ships
- Capacity elsewhere is sufficient to meet demand meaning there is little appetite for new suppliers

## Power conversion manufacture

For the purposes of this study, power conversion manufacture and drivetrain manufacture are analogous and as such have similar opportunities.

Current suppliers include ABB, The Switch, Siemens and GE.

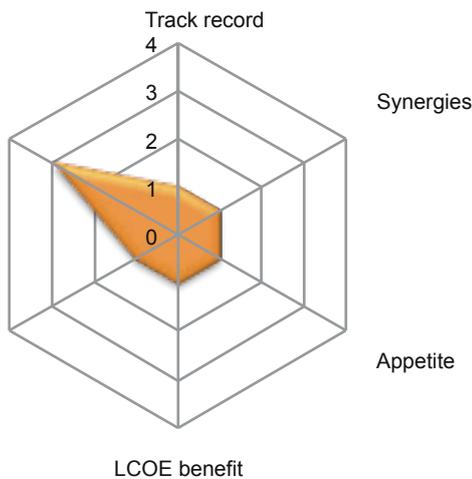
We concluded that power conversion manufacture is a small opportunity for the Norwegian supply chain.

The assessments are summarised in Figure 17.

Source: BVG Associates

Size of the opportunity

Size and timing of investments



**Figure 17 Summary of the assessment for power conversion manufacture.**

## Large fabrications manufacture

Turbine components, such as the hub, the nacelle bedplate and housings for the bearings and gearbox, are spheroidal graphite iron castings. Stronger steel forgings that can be reliably welded are used for bearings, shafts, gear wheels and tower section flanges.

Current suppliers include Grupo Euskal, Liebherr, Sakana and Siempelkamp.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- We have identified no supply from Norwegian companies
- Synergies are few with other offshore and maritime industries. Volumes in offshore wind are higher than in other industries which presents manufacturing challenges for those used to supplying similar sized components to other industries in smaller numbers.
- Large fabrications in offshore wind are becoming increasingly commoditised, leading to greater sourcing from low-cost countries
- Alternatives to cast iron may be introduced in the mid-term, which may reduce costs, although we have not seen evidence that Norwegian companies have unique solutions
- Significant investment in quayside manufacturing facilities is required for new entrants; it is likely that agreements with multiple turbine manufacturers serving multiple markets will be required to justify investment and this will be difficult to achieve
- The size of the opportunity is only moderate.

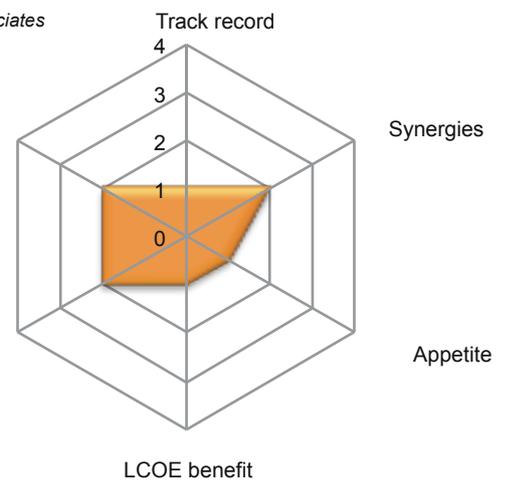
*We have concluded that the opportunity for the Norwegian supply chain to enter the large fabrication market is small because overall there is a lack of experience and much of the supply is shifting to low cost countries.*

The assessments are summarised in Figure 18.

Source: BVG Associates

Size of the opportunity

Size and timing of investments



**Figure 18 Summary of the assessment for large fabrications manufacture.**

## Towers

Towers for offshore wind turbines are welded conical structures manufactured from several rolled steel cans. They are shot blasted and surface finished inside and out. The tower sections are then fitted out with ladders, platforms, safety and electrical equipment including switchgear. There are typically three of these sections that are bolted together at the construction port prior to transport and installation at the site.

Current suppliers include Ambau, CS Wind, Titan Wind Energy, Valmont SM and Windar.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- There has been little supply from the Norwegian supply chain
- Synergies are moderate because marine structures have not been produced in the volumes expected by offshore wind
- The market for towers supports few suppliers and margins are low. An opportunity for Norwegian companies may lie in providing internal platforms, safety equipment and lighting but there is strong competition from companies already supplying the onshore and offshore markets.



- Costs are dominated by the steel price which limits the opportunity for Norwegian suppliers to impact LCOE
- Investment in new tower facilities needs to be aligned with the demand from wind turbine manufacturers. Existing suppliers are more likely to be able to deliver such investments in time.
- The size of the opportunity is high given the lifetime spend in this area.

## Small components

There are many small components in a wind turbine such as lighting, communication systems and doors, all of which have been supplied by Norwegian companies. There are also a number of small machined and fabricated parts. This includes plates, shafts, pins, brackets, rails, flooring and ladders.

There is a lot of diversity in small components and therefore there are many suppliers.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- There have been some isolated successes by the Norwegian suppliers, including Øglænd Systems supplying support and cable management systems
- Synergies are moderate because the volumes expected in offshore wind are higher than in parallel sectors
- The turbine manufacturers tightly control their vendor lists making market entry challenging
- Most of the small components are standardised limiting the opportunities for cost reduction from a new supplier
- Investment in tooling may be required to support offshore wind specific challenges
- The size of the opportunity is moderate.

*We have concluded that the opportunity for the Norwegian supply chain in the small component market is weak. Overall, despite some Norwegian suppliers in the sub-element, the number is still relatively low meaning that experience on the whole is limited.*

The assessments are summarised in Figure 20.

The assessments are summarised in Figure 19.

Source: BVG Associates

Size of the opportunity

Size and timing of investments

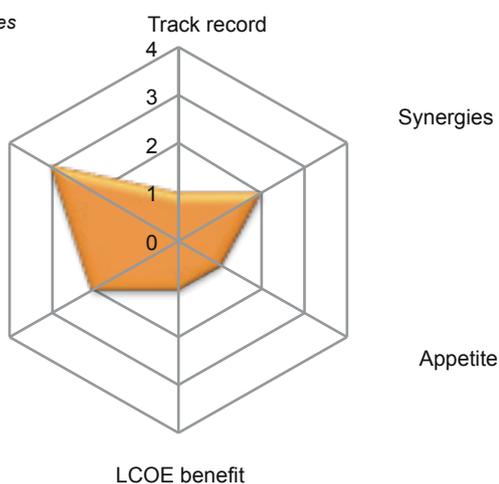


Figure 19 Summary of the assessment for towers.

Source: BVG Associates

Size of the opportunity

Size and timing of investments

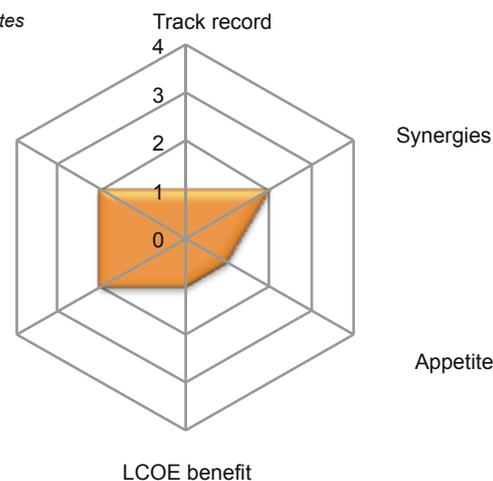


Figure 20 Summary of the assessment for small components.

## 6.4. Balance of plant

Balance of plant covers the non-turbine-related wind farm infrastructure, such as cables, substations and foundations. These contracts make up 19% of the lifetime spend of an offshore wind farm, as shown in Table 4.

There will be important developments in the technology used in balance of plant packages as wind farms are built further offshore, in deeper water and with larger turbines.

There are opportunities for innovative suppliers from parallel sectors. Synergies are particularly strong with the offshore oil and gas and shipbuilding sectors, which have expertise in building large marine structures, cables and steel work.

Figure 21 shows the cost breakdown of the balance of plant sub-element.

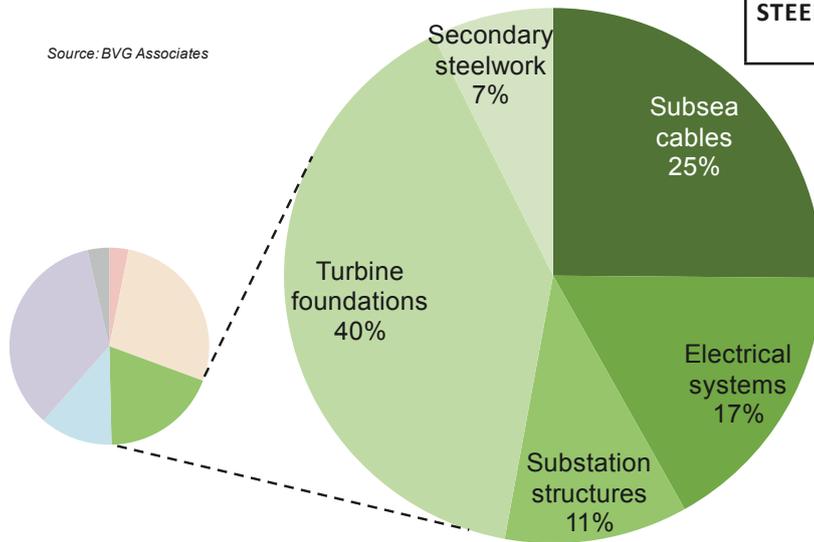


Figure 21 Breakdown of balance of plant sub-element.

Table 4 Summary of balance of plant opportunity.

| Sub-element                           | Lifetime spend for a 1GW wind farm | Norwegian opportunity |
|---------------------------------------|------------------------------------|-----------------------|
| <b>SUBSEA CABLES</b>                  | 4.8%<br>2,640 kr million           | Green                 |
| <b>ELECTRICAL SYSTEMS</b>             | 3.2%<br>1,760 kr million           | Yellow                |
| <b>OFFSHORE SUBSTATION STRUCTURES</b> | 2.1%<br>1,160 kr million           | Green                 |
| <b>TURBINE FOUNDATIONS</b>            | 7.6%<br>4,180 kr million           | Green                 |
| <b>SECONDARY STEELWORK</b>            | 1.4%<br>770 kr million             | Yellow                |

### Box 4 Norwegian supply chain expertise

Norway has expertise across the balance of plant value chain, including main component suppliers, main contractors, equipment suppliers and service providers.

#### Main component suppliers

Two of the leading subsea cable manufacturers have facilities in Norway. Prysmian (Draka) has subsea cable manufacturing capabilities in Drammen and Nexans has its high voltage factory at Halden. Aibel and Kværner have both supplied substation structures.

#### Main contractors

ABB is a key supplier of electrical systems and has a number of facilities in Norway. It has also partnered with Aibel on the Dolwin Beta converter platform.

#### Equipment suppliers

Norwegian companies are active in supplying equipment; examples include cable protection (Seaproof Solutions and Trelleborg Offshore) and corrosion protection (Imenco and Jotun).

#### Service providers

Service providers include the design and licensing of innovative foundation solutions from suppliers such as Seatower, OWEC Tower and Dr.techn.Olav Olsen.



## Subsea cables

Subsea cables deliver the power from the turbines to the onshore grid. Array cables connect the turbines to an offshore substation from which the power is transmitted to an onshore substation via high voltage (HV) export cables.

To date, array cables have predominantly been medium voltage (MV) and rated at 33kV using copper or aluminium cores. The technology is well established and has been extensively used in the power and oil and gas industries. Contracts have recently been awarded for the supply of 66kV cables and this is expected to be a rapidly growing market over the coming years.

Export cables have a significantly higher capacity than array cables, ranging from 132kV to 245kV with copper or aluminium cores. Export cable installation takes place early in the construction schedule and there are potentially long lead times. It is therefore one of the first contracts placed.

Most export cables have been alternating current (AC) but the development of projects further from shore is likely to lead to greater use of direct current (DC) systems.

MAKE's 2016 report on *Norwegian Opportunities in Offshore Wind* prepared for INTPOW, Export Credit and Greater Stavanger reported that Norwegian companies secured 28% of array cable supply from 2010 to 2016. This has however dropped to 4% for projects to 2020. Nexans supplied 20% of export cables from 2010 to 2016; this has dropped to 9% for projects to 2020.

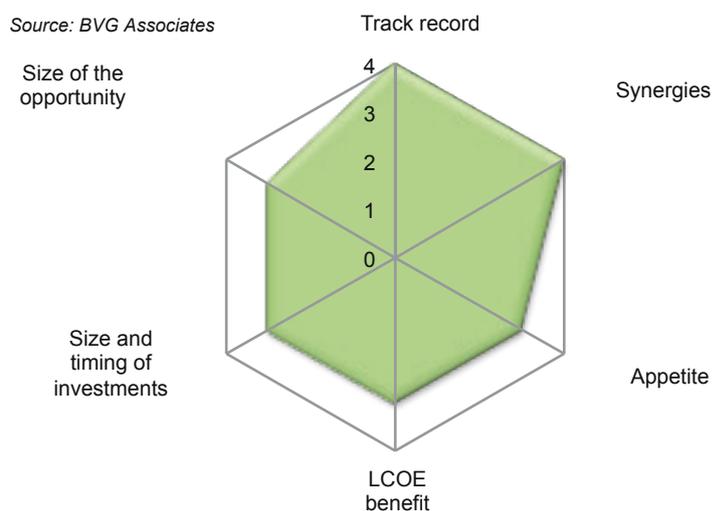
Current suppliers include JDR Cables, Nexans, NKT Cables, NSW (General Cable) and Prysmian.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Two of the leading cable companies in offshore wind, Prysmian and Nexans have a manufacturing presence in Norway. Other Norwegian suppliers have provided cable accessories.
- Synergies are strong with the offshore oil and gas sector, which has experience in developing complex cables and the associated components such as connectors and terminations
- The market is already well served. Volumes for components such as connectors are higher in offshore wind than in the oil and gas sector which increases demand.
- Oil and gas companies can also bring their expertise in design, reliability and dynamic cables (which will be important for floating offshore wind)
- Most suppliers to the oil and gas umbilicals market will be able to supply offshore wind without significant investment
- The size of the opportunity is high.

*We have concluded that manufacture and supply of sub-sea cables presents a major opportunity for the Norwegian supply chain because overall the synergies are very strong with existing activities, leading suppliers have facilities in Norway and the proportion of lifetime spend is high.*

The assessments are summarised in Figure 22.



**Figure 22 Summary of the assessment for subsea cables.**

## Box 5: Subsea cables

**Company:** Nexans

**Sub-element:** Subsea cables

**Company background:**

Founded in 2000, Nexans is one of the largest cable OEMs globally with an industrial presence in 40 countries, commercial activities worldwide, close to 26,000 employees and annual generating sales of close to €6 billion. The company has developed an extensive range of cables and cabling solutions that deliver increased performance for customers worldwide. Nexans serves customers across the industrial spectrum under four business units: Power transmission and distribution (submarine and land), Energy resources (oil and gas, mining and renewables), Transportation (road, rail, air, sea) and Building (commercial, residential and data centres). With strong capabilities in the production of medium and high voltage cables, Nexans can oversee complete installation, from initial pre-qualification, design, customized production, logistics, installation, testing and pre-commissioning. Nexans has developed the necessary expertise to outfit large offshore wind turbines, interconnect them in complete windfarms, and link them to distant or local grids.

**Task:**

The offshore wind industry is a fast growing industry and as a consequence there is a high focus on cost reduction to make it sustainable compared with other sources of energy. As a viable solution, production costs have had to be reduced both in terms of hardware (wind turbines), control software, and transmission infrastructure.

With larger and more efficient turbines hitting the market at a rate of pace, transmission systems have had to be adapted to be able to transmit the required power. At the same time, wind farms are now generally being located further from shore and in deeper waters and this trend will continue. Consequently, wind farms are situated in places where wind and waves makes installation of equipment challenging.

In order to foster innovation whilst at the same time reducing cost, the offshore wind sector has had to proactively develop supply partnerships and promote trans-regional cooperation. This is especially crucial in research, technological development and training. International projects require specialized cable expertise, shared knowhow, and the development of and adherence to world standards.

**Action:**

Nexans has become a world-class supplier of submarine and underground cables, overhead conductors and data/telecom systems by fostering close partnerships with developers, power utilities, installers and contractors. From decades of operation in challenging waters, Nexans has attained unsurpassed offshore installation and topside termination experience using advanced equipment, special software for overhead lines, and dynamic cable solutions.

Nexans has invested heavily in its product range and can offer the offshore wind sector a number of solutions including power accessories such as separable connectors, cold-shrinkable and heat-shrinkable joints and terminations for various types of cable, mechanical connectors, and cable lugs and pre-manufactured cable kits for offshore wind turbine manufacturers seeking reliable connectivity. In addition, Nexans has developed a system solution for turbine transition piece where junction frames or cabinets assure the link between an inter array cable and the switch in the basement of the tower.

**Outcome:**

Nexans has been a leading player in the offshore wind industry since its inception. Cable designs, installation methodologies as well as production and installation capacity have all been developed in line with changing customer demand. Nexans was the first manufacturer to develop and introduce 3-core 170 kV and 3-core 245 kV XLPE cables to the offshore wind market, both of which became standard transmission solutions for exporting power from the offshore wind farm to the onshore grid. Furthermore, Nexans has also introduced 66 kV inter array cables to the market and will supply cables to the first windfarm operating at this voltage.

By engaging with clients during the early phase of a project, Nexans adds value by applying its competence and experience when projects are shaped. Nexans will continue to develop, manufacture and supply products and solutions to help meet tomorrow's demand and create a bright and sustainable future.





## Electrical systems

Almost all commercial-scale offshore wind farms have involved at least one offshore substation, incorporating electrical components such as reactive compensation systems, switchgear, transformers, back-up generators and converters where required.

HVAC electrical systems have been the most common solution to date. For projects that are built further offshore, however, there is cost benefit in using HVDC systems due to reduction in electricity losses.

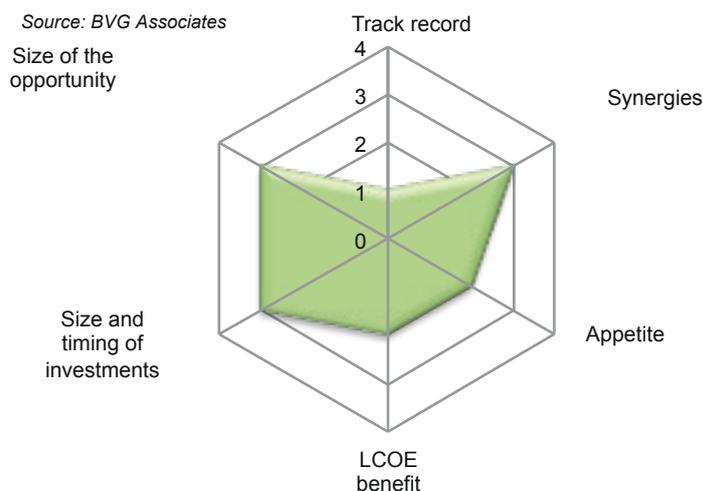
Current suppliers include ABB, CG Power, GE Grid Solutions and Siemens Energy Transmission.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- There has been limited involvement so far from Norwegian suppliers. Engineering work is mainly done in the domestic market of the wind farm and few electrical components have been supplied from Norway.
- Synergies are good with onshore infrastructure of offshore interconnector projects. Norwegian companies have good experience with interconnectors to Netherlands and Denmark.
- The electrical components that are required for an offshore substation are standard with a number of suppliers already established which limits opportunities for new entrants
- There is considerable interest in compact electrical systems as a means of reducing LCOE through a reduced requirement for offshore infrastructure
- Significant capital investment is not required. The electrical suppliers will build design teams for offshore wind as required by the contracts being secured. Investments to increase capacity for component manufacture are generally not large.
- The size of the opportunity is medium given the lifetime spend in this area.

*We have concluded that the electrical systems market presents a good opportunity for the Norwegian supply chain because overall the synergies are very strong with existing activities, minimal investment is required for suppliers to parallel sectors to diversify and the lifetime spend is reasonably high.*

The assessments are summarised in Figure 23.



**Figure 23 Summary of the assessment for electrical systems.**

## Offshore substation structures

Offshore substation platforms are large complex steel structures. An HVAC offshore substation platform weighs up to 2,000t and may include a helipad and emergency accommodation. HVDC substations are much larger, with masses of up to 15,000t. Substation manufacturing is analogous to shipbuilding and offshore oil and gas platform fabrication. Large steel modules are fabricated, with complex systems then integrated.

Current suppliers include Babcock, Bladt, Fabricom, Harland & Wolff, Hollandia and Navantia.

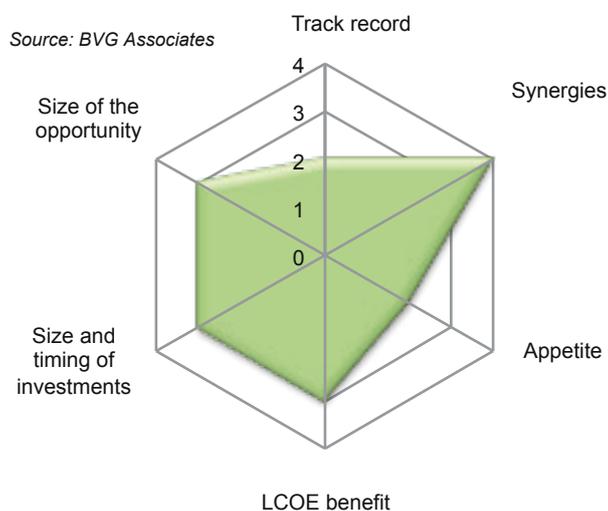
Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- ABB has partnered with Norwegian supplier Aibel to deliver substations for the offshore wind sector. Aibel will take responsibility for the substation structures while ABB will focus on the electrical elements. Aibel and ABB developed a self-installing gravity base structure platform design for Dolwin 2. Equipment suppliers such as Solid Vedlikehold, Jotun and Imenco have won corrosion protection contracts.
- Synergies are strong with both shipbuilding and offshore oil and gas platform fabrication. Conventional substations are built on the quayside whereas self-installing substations require a dry dock.
- The market for offshore substations has become increasingly competitive with 12 or more suppliers bidding for many projects
- Next generation offshore substations incorporating accommodation or built into the turbine foundation may provide opportunities to support innovation and reduce LCOE. Substation structures are usually bespoke; standardisation and simplification may reduce costs significantly.

- Significant investment is not required for HVAC substations, however the larger HVDC designs may need infrastructure improvements
- The size of the opportunity is medium.

*We have concluded that the offshore substation structures market presents a major opportunity for the Norwegian supply chain because overall the synergies are very strong with existing activities, there is already good experience in Norway and there is the potential for Norwegian suppliers to make a difference.*

The assessments are summarised in Figure 24.



**Figure 24 Summary of the assessment for substation structures.**

## Turbine foundations

Turbine foundations represent a major part of a project's capital expenditure. Developers select a foundation technology depending on the water depth, sea bed conditions, wave and tidal loading, and turbine loading, mass and rotor speed. The options are summarised below:

### Monopile structures

To date, most offshore wind farms have used steel monopile foundations which are driven into the sea bed. The development of projects in deeper water with larger turbines has led to the development of increasingly large designs, with units up to 1,200t currently being deployed.

### Jacket structures

Jacket foundations are cross-braced, welded, space-frame structures. Other space-frame designs, such as tripods and tri-piles, have also been used on German projects but their cost means their future role is likely to be limited.

There is significant interest in suction buckets as sea bed connections as a means of lowering installation costs and the impact of piling on wildlife.

### Gravity-base structures

Gravity-base structures (GBSs) are assembled onshore and installed without the need for piling. This avoids some of the noise restrictions faced by some projects to limit the impact on marine mammals and eliminates the need for expensive heavy-lift vessels. Large quayside or dry dock facilities are required with heavy lift capabilities for manufacture. These are made from concrete or are steel-concrete hybrids.

### Floating structures

Floating offshore wind provides opportunities to move into deeper waters with high wind resource where fixed-bottom foundations cannot be deployed. Currently, floating wind farms have a higher cost of energy than fixed but there is growing confidence that they could be competitive by 2030. Advantages are the lower installation cost and the ability to standardise designs within and between wind farms. This technology is still at the pilot stage.

There are three main types of floating offshore wind structure:

- Tension leg platform
- Semi-submersible platform, and
- Spar buoy.

All of these concepts have been widely used in the oil and gas sector, although loading requirements and commercial models are very different. Norwegian developer, Statoil, has installed its Hywind spar buoy in Norway and is currently installing a demonstration array in Scotland.

MAKE's 2016 report on *Norwegian Opportunities in Offshore Wind* prepared for INTPOW, Export Credit and



## Box 6: Offshore substation structures

**Company:** Aibel

**Sub-element:** Offshore substation structures

### Company background:

Aibel is a leading supplier of services related to oil, gas and renewable energy, with more than a hundred years of history. The company is headquartered in Norway, and has a global presence with both offices and yards in Europe and Asia.

Within oil and gas, Aibel has substantial experience with EPCI project execution for new offshore installations and onshore plant. In addition, the company has long term onshore and offshore O&M contracts on the Norwegian continental shelf and can also provide hook-up, assembly, completion and commission of platforms. The largest project that is currently ongoing is the EPC project execution for Statoil's Johan Sverdrup Drilling Platform.

Within offshore wind, Aibel designs, builds and installs platforms for converting alternating current to direct current (complete HVDC transmission systems). In the summer of 2015 Aibel delivered its first converter platform, DolWin Beta. The platform, which is installed in the German sector of the North Sea, has the capacity to receive 916 MW of power. The platform concept was developed in collaboration with ABB, where Aibel provided the design, fabrication and installation of the platform. The concept is based on proven technology from the oil and gas industry.

### Task:

The offshore wind industry has seen a significant reduction in the cost of energy over the last years. However, the industry still needs to incorporate further cost reductions in order to be sustainable in the long term without the need for subsidies. This includes all elements of developing offshore wind farms, where concept development and disruptive technologies in high cost areas such as substations can play an important role.

### Action:

Aibel believes that future solutions incorporating cost effective solutions for both CAPEX and OPEX, can be developed in a partnership between designers, producers and customers in order to reach the full potential of offshore wind. Aibel is therefore focused on developing its own concepts and solutions based on customer and market requirements.

### Outcome:

Aibel delivers both larger HVDC platforms for use far from shore, and smaller AC substations that are suitable for near shore solutions. In addition, Aibel have been awarded an extensive contract for Statoil's Hywind Scotland Pilot Park Project which includes front end engineering design (FEED), Engineering and Management assistance (EMa), the design of towers, procurement of equipment, responsibility for system integration and installation assistance.

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Greater Stavanger reported that Norwegian companies, led by Kvaerner Verdal, secured 3% of turbine foundation supply from 2010 to 2016. This has however dropped to zero for projects to 2020 with Kvaerner Verdal's decision not to tender contracts.

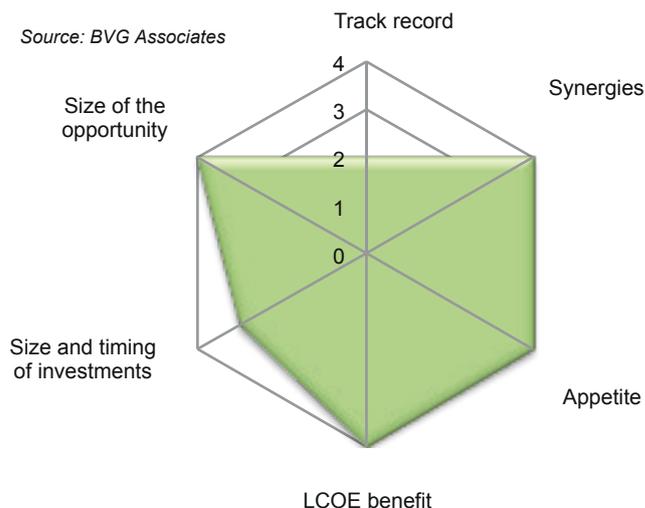
Current suppliers include Bladt Industries, BiFab, EEW Special Pipe Constructions, Navantia, Sif Group, Smulders Projects and Steelwind Nordenham.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Norwegian suppliers are active in developing innovative turbine foundation solutions. These include Statoil, OWEC Tower, Universal Foundation, Seatower and Dr.techn. Olav Olsen. In spite of this, the number of foundations manufactured in Norway is limited to the supply of jackets by Aker for a German project from the Verdal yard (now owned by Kvaerner).
- Synergies are strong with offshore oil and gas fabrication in which Norway has the expertise and supporting infrastructure. Many of the foundation types under development are well established in the oil and gas sector, although there are some important differences.
- New entrants from the oil and gas sector with the infrastructure and track record would be welcomed by developers if they make investments in serial manufacturing facilities
- Norwegian companies are developing innovative foundation solutions as described above it is important for these suppliers to demonstrate the impact that their technologies will have on LCOE
- Norway has good infrastructure for these activities so investments will be moderate
- The size of the opportunity is high.

*We have concluded that the fabrication and supply of turbine foundations presents a major opportunity for the Norwegian supply chain because overall the synergies are very strong with existing activities, the opportunity exists for Norwegian companies to provide innovative solutions and this represents a large proportion of the lifetime spend.*

The assessments are summarised in Figure 25.



**Figure 25 Summary of the assessment for turbine foundations.**



## Box 7: Turbine foundations

**Company:** OWEC Tower AS

**Sub-element:** Turbine foundations

### Company background:

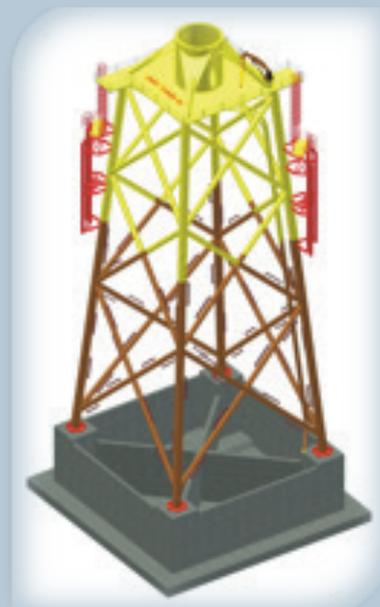
OWEC Tower is a leading design and engineering company providing complete foundation solutions and general consultancy services to the global offshore wind market. OWEC Tower was established in 2004 building on experience in addressing design issues in the offshore oil and gas industry. OWEC is now a subsidiary of the wider Keppel Group. Headquartered in Oslo, the team consists of highly qualified and experienced engineers, researchers and designers developing both fixed and floating, steel and concrete offshore wind foundations.



### Task:

OWEC recognised the challenge to develop a jacket structure for offshore wind before 2000. Coming from the oil and gas sector it recognised that the way of addressing the design issues for a wind turbine was different. This was the basis for the business idea that shaped the company. The company developed new calculation tools that today form an integrated part in standard calculation packages.

Today, many years later, OWEC has invested in design capabilities and consequently has a wide range of solutions fitting different site needs. It also has a big database, enabling swift and accurate design. One of the challenges has been the large variety in designs and the difficulty in keeping well informed about such a rapidly evolving market. A proven design and track record with cost efficient solutions has been a major reason for the success of Owec Tower.



### Action:

To mitigate against these challenges, the company has continuously invested in its people and developed its design tools.

The market has been addressed by focussing on track record and communicating with the whole value chain of a project, starting with the developer and then advising on fabrication and installation. The team has had many face-to-face meetings with clients, combined with events and collaborations with research institutions. It has been important to participate in technical workshops and technical events. Success in international markets has been based on partnerships with local engineering companies and others which have a good reputation in the local market.

### Outcome:

Today OWEC is a globally recognised engineering and consultancy firm with activities in Europe, Asia and North America. OWEC has supported multiple offshore wind farms including Beatrice, Alpha Ventus, Ormonde, Thornton Bank and Le Carnet.

## Secondary steelwork

Secondary steel on offshore wind foundations, towers and substations can include plate beams, railings, barriers, rescue support frames, J-tubes (steel tubes protecting array cables) and boat landing systems. Secondary steelwork can be designed and fabricated off-site from the location of foundation manufacturing.

Unlike many of the sub-elements, there is no need for coastal locations as in many cases the components can travel by road.

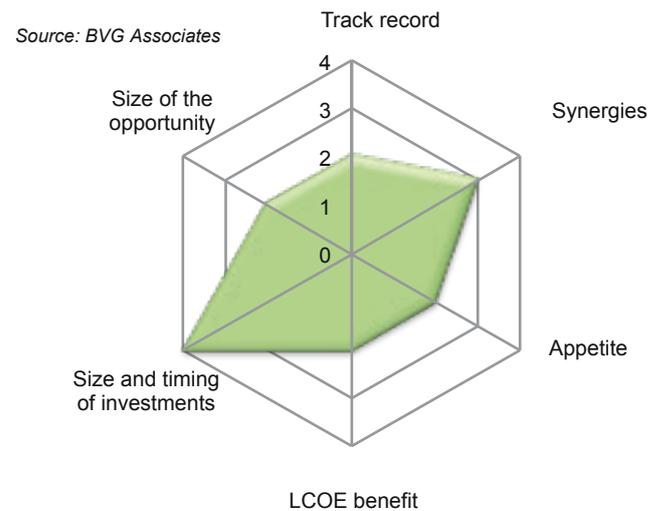
Current suppliers include Hutchinson Engineering, MTL and Wilton Engineering in the UK.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Secondary steelwork may be seen as an opportunity for developers to increase local content, the lack of a pipeline of projects in Norway may limit the opportunities for Norwegian suppliers
- Synergies with small steel fabrications for maritime industries are good
- Many of the items supplied to this sub-element are viewed as commodity items so price is the overriding factor once quality thresholds are met
- The price of steel is the dominant factor for these items with opportunities to reduce costs through automation
- Norway has good infrastructure for these activities so any investments will be moderate
- The size of the opportunity is moderate.

*We have concluded that the secondary steelwork market presents a good opportunity for the Norwegian supply chain because overall the synergies are good with existing activities and there is little investment required in order to diversify.*

The assessments are summarised in Figure 26.



**Figure 26 Summary of the assessment for secondary steelworks.**



## 6.5. Installation and commissioning

Installation and commissioning activities make up about 12% of the lifetime spend of an offshore wind farm, as shown in Table 5.

Use of ports, associated logistics and onshore works make up a small part of this element and in most cases are local to the offshore wind farm. Norway's lack of a pipeline of projects means that opportunities in these sub-elements are limited to consultancy and engineering studies.

Although many of the personnel involved in installation work have a background in the existing offshore energy supply chain, few of these companies have a track-record in turbine and foundation installation, which makes up the largest proportion of this area. Most of the vessels used are often high-specification jack-up vessels designed for offshore wind. Most were built in the Gulf states or east Asia. For example, the two Fred. Olsen Windcarrier vessels were built at the Lamprell Yard in Dubai.

The barges used to float substations out to the wind farms can service multiple sectors. The substations are then installed at sea using a heavy lift vessel. There are few vessels with the lifting capacity required to lift a substation topside. Substation installation often forms part of the substation electrical system contract. The substation foundation is often installed by the turbine foundation installer if the same technology is used. This enables a more flexible installation campaign and reduces mobilisation costs.

Cable installation is another sub-element with good synergies with the Norwegian supply chain. Vessels from the oil and gas sector have been used extensively for cable installation and Norwegian shipyards have modified and built cable vessels. The trend is for purpose-built cable vessels to increase the speed and efficiency of installation.

Table 5 Summary of installation opportunity.

| Sub-element                                 | Lifetime spend for a 1GW wind farm | Norwegian opportunity |
|---|------------------------------------|-----------------------|
| INSTALLATION PORTS AND LOGISTICS            | 0.6% 330 kr million                |                       |
| TURBINE AND FOUNDATION INSTALLATION         | 4.9% 2,700 kr million              |                       |
| CABLE INSTALLATION                          | 2.4% 1,320 kr million              |                       |
| SUBSTATION INSTALLATION                     | 0.4% 220 kr million                |                       |
| INSTALLATION EQUIPMENT AND SUPPORT SERVICES | 3.0% 1,650 kr million              |                       |
| ONSHORE WORKS                               | 0.6% 330 kr million                |                       |

Installation contractors have a supply chain for equipment and services that often work across the offshore energy sectors. Since many of these companies are SMEs, offshore wind can be a significant area of business.

Figure 27 shows the cost breakdown of installation and commissioning sub-element.

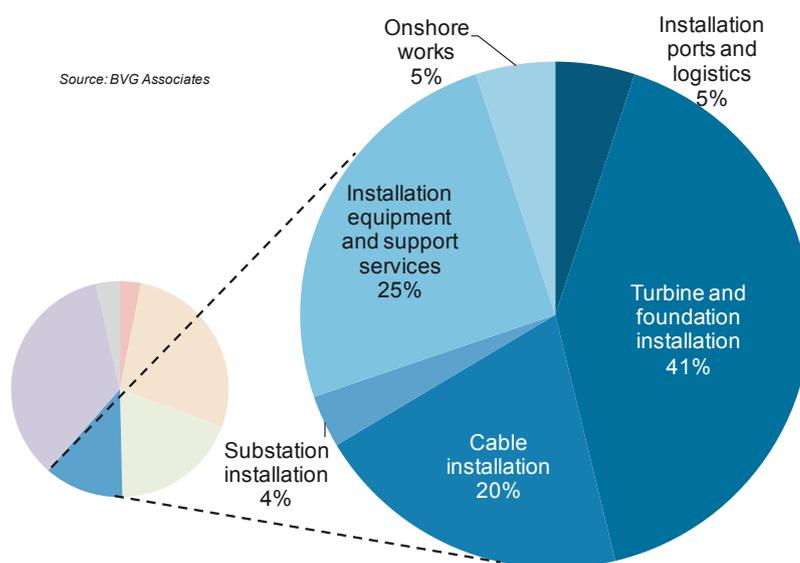


Figure 27 Breakdown of installation and commissioning sub-element.

## Box 8 Norwegian supply chain expertise

Norway has significant expertise across the installation and commissioning value chain, including main component suppliers, main contractors, equipment suppliers and service providers.

### Main component suppliers

The main components used in installation and commissioning are jack-up vessels, heavy lift vessels, cable vessels, and construction support vessels. Norway's strengths are in cable vessels (for example the Kleven shipyard), and construction support vessels (for example Batservice Mandal, Havyard and Ulstein)

### Main contractors

Fred. Olsen Windcarrier is one of the leading offshore wind installation contractors. DeepOcean and Siem Offshore, through its subsidiary Siem Offshore Contractors, are leading Norwegian cable installers. Solstad Offshore vessels have been used for several offshore wind farms.

### Equipment suppliers

Norwegian companies are active in supplying equipment, particularly for cable installation, including carousels and tensioners (for example Drammen Yard, Sepro Technology). It also has expertise in lifting equipment (Ace Winches Norge) and motion compensated gangways (Uptime, MacGregor, Kongsberg Maritime) and navigation equipment (Simrad).

### Service providers

Service providers include the operation of construction support vessels (Fred. Olsen, Havila, Simon Møkster and others), communication services, ship brokers, consultancies and metocean and meteorological services (Miros and StormGeo).

## Installation ports and logistics

An installation port is the location where the main wind farm components are gathered and pre-assembled prior to being loaded onto an installation vessel. Installation ports are normally selected for proximity to the wind farm.

A number of offshore wind companies have signed agreements with ports including Ostend, Hull, Esbjerg, Eemshaven and Vlissingen.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

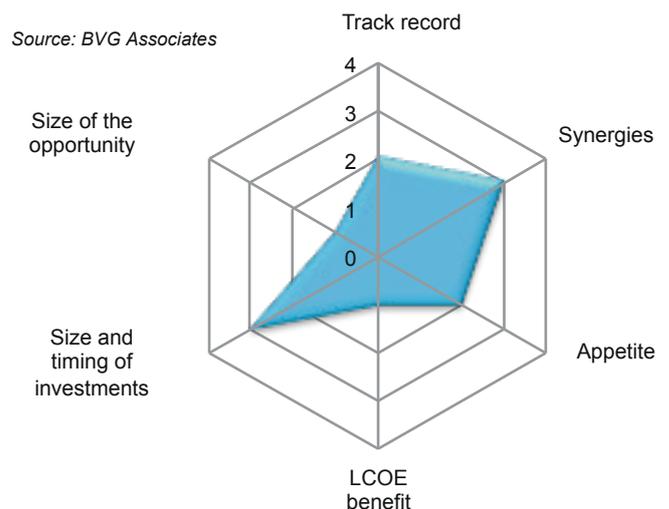
- NorSea Group's Stordbase AS is being used for the one-off assembly of Statoil's Hywind demonstration project in Scotland. There is also some experience through NorSea Group's subsidiary Danbor, which operates ports in Denmark and established NSG

Wind. Overall, Norway only has a small demonstration offshore wind turbine in operation and no near-term pipeline of projects, there is therefore no requirement for installation ports at this time.

- Norway's existing offshore supply chain includes a number of ports capable of supporting the specialist installation vessels used in offshore wind including jack-up vessels and heavy lift vessels
- Given the lack of a pipeline of projects in Norway, there is little appetite from the offshore wind industry to establish Norwegian installation ports. This may increase if a market emerges for floating offshore wind.
- Innovations in port operations transferred from the existing offshore supply chain will only have a negligible impact on LCOE
- It is difficult to justify the infrastructure investment for a single project, which will last as little as three years, therefore port investments have been made to service a number of wind farms in the region.
- The size of the opportunity is small.

*We have concluded that the installation ports and logistics market presents a weak opportunity for the Norwegian supply chain because overall there isn't a pipeline of projects to support what is primarily a local activity.*

The assessments are summarised in Figure 28.



**Figure 28 Summary of the assessment for installation ports and logistics.**



## Turbine and foundation installation

Turbine installation is undertaken using jack-up vessels which transport wind farm components from port to site. Recent projects have mostly used vessels purpose built for offshore wind. It takes two to three days to install a turbine on average, including transit time, weather downtime and mobilisation/demobilisation time. The installation work is undertaken by the turbine manufacturer but the vessel is often contracted by the developer. Turbine installation may form part of a full balance of plant EPCI contract.

For foundations, vessels may either transport the structures from port to site and undertake the installation, or remain onsite with foundations transported to site using feeder vessels. Some of the vessels used are jack-ups and are used for both turbine and foundation installation. Others are floating heavy lift vessels, which may be used for other maritime sectors. For jacket foundations, deck space is the limiting factor for vessel choice whereas for monopile foundations it is increasingly the crane capacity.

It takes about three days to install a monopile and five days to install a jacket foundation, including transit time, weather downtime and mobilisation/demobilisation time.

As described in the 2016 report, *Norwegian Opportunities in Offshore Wind*, Eide Marine Services was the only Norwegian foundation installer from 2010 to 2016. Norwegian suppliers are yet to win contracts for the period to 2020 but 27% of these contracts are yet to be awarded. For turbine installation, Fred. Olsen had 9% of the market from 2010 to 2016 and currently has contracts for 18% of the project backlog.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

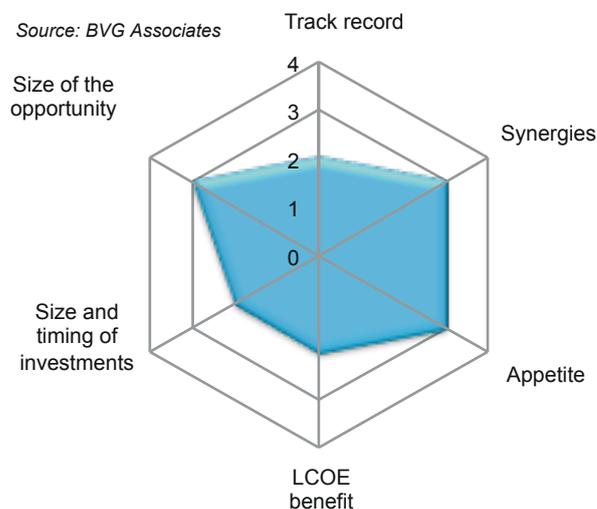
- A small number of Norwegian companies have been directly involved in turbine and foundation installation, including Eide Marine Services and Fred. Olsen Windcarrier. Lower tier contracts have been awarded to vessel suppliers such as Reach Subsea and Odfjell Wind and consultancies such as Semar
- Most installation vessels are designed specifically for offshore wind, limiting the opportunity for transfer from other offshore sectors where Norway has strengths. Norwegian shipyards, which have supported the existing offshore supply chain, have not been able to compete with overseas yards to build turbine or foundation installation vessels.
- The market is undergoing consolidation, with the Dutch and Belgian dredgers strengthening their market positions. They offer either transport and installation or EPCI packages, depending on the preference of the developer. Wind farm developers

have however demonstrated a willingness to use Norwegian installation contractors. Fred. Olsen Windcarrier is one of the leading contractors in the industry for turbine installation.

- Innovations in vessel design which allow installation at increased depth will help the industry access better resource in deeper waters. Norwegian companies that can address the challenges of installation in deep waters (>45m) will be in a strong position. Reducing the weather sensitivity of installation is another key driver for cost reduction and there is likely to be an opportunity for offshore engineering companies to play a part.
- Investing in new bespoke vessels or company acquisitions would be required for Norwegian suppliers to develop their presence.
- The size of the opportunity is reasonably high.

*We have concluded that turbine and foundation installation presents a good opportunity for the Norwegian supply chain because overall the synergies are high; however, investment is required and well established suppliers are consolidating their position.*

The assessments are summarised in Figure 29.



**Figure 29 Summary of the assessment for turbine and foundation installation.**

## Cable installation

Cable installation can be undertaken either in a single lay and burial process using a plough or via a separate surface lay and subsequent burial approach using a jetting tool on an ROV.

Installation of array cables is more challenging due to the large number of operations involved, with a pull-in at each foundation. For nearshore installations, shallow-draft barges are often used; while large scale projects further from shore typically use dynamically positioned cable ships.

Export cables are typically installed as a single length of cable and thus larger vessels are used with the necessary storage. Unlike turbine and foundation installation, success in the cable installation market is driven as much by technical capability and track record as it is by vessel capability.

The 2016 report on *Norwegian Opportunities in Offshore Wind* found that Norwegian owned cable installation companies had 19% of the 2010 to 2016 market with this growing to 23% for projects to 2023.

Current suppliers include DeepOcean, Jan De Nul, Siem Offshore Contractors, Tideway, Van Oord and VBMS.

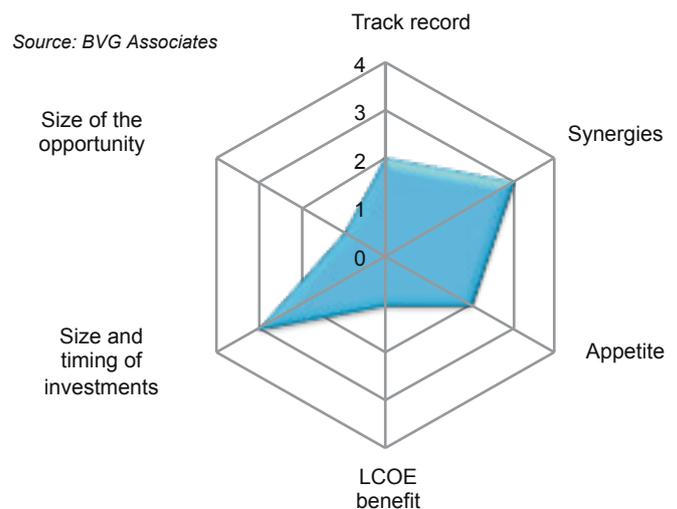
Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Norwegian suppliers have a good track record in undertaking cable installation. Nexans operates its cable vessel Skagerrak from its Halden plant. In the past Norwegian offshore fleets (for example, GC Rieber and Solstad Offshore) provided vessels converted for cable installation. DeepOcean and Siem Offshore Contractors have Norwegian parent companies but their operations are mainly based in the UK and Germany respectively. Norway also has the capability to build cable vessels; NKT Cables has just taken delivery of a new installation vessel from Kleven shipyard in Norway. Norway also has several suppliers of cable equipment and services (see later).
- Companies active in the Norwegian offshore supply chain have entered the market. Synergies with other subsea installation activities are high. Challenges specific to offshore wind include the large number of complex operations undertaken over a large area and the different procurement culture among developers.
- The available fleet of cable laying vessels is large but not all the vessels are optimised for the sector. This creates opportunities for Norwegian suppliers although most new vessels are being built at low-cost European yards.

- Access to the turbine transition piece to perform tests and complete terminations is often a limiting step due to limited weather windows. Technologies which improve access or reduce the need for this step will impact LCOE.
- There is sufficient capacity in the long term to meet the demand although most vessels are also used in other sectors. Investments by companies can be made incrementally to meet demand.
- The size of the opportunity is moderate.

*We have concluded that cable installation presents a good opportunity for the Norwegian supply chain because overall Norwegian companies are able to support cable installation across the supply chain. The market is well served for installers, including some Norwegian suppliers. Shipyards may be able to identify individual opportunities for vessel construction or modification.*

The assessments are summarised in Figure 30



**Figure 30 Summary of the assessment for cable installation.**



## Substation installation

Offshore substation electrical systems are mounted on platforms. These structures are often similar to offshore oil and gas platforms, as is the installation process, although substations are typically in shallower water. The mass of topsides is variable and can depend on the choice to have one or two platforms for a wind farm. In general these have typically been installed with a single lift from a barge. Both sheerleg and heavy lift vessels can undertake the lift from the barge. Substation foundations may be either jackets or monopiles, and the installation of these may form part of the turbine foundation installation contract and use the same vessels.

According to the 2016 report on *Norwegian Opportunities in Offshore Wind*, there are no contracts secured for Norwegian companies in substation installation to 2020. Historically, Eide Contracting installed gravity based foundations for substations, however this technology has failed to compete with monopiles and jackets.

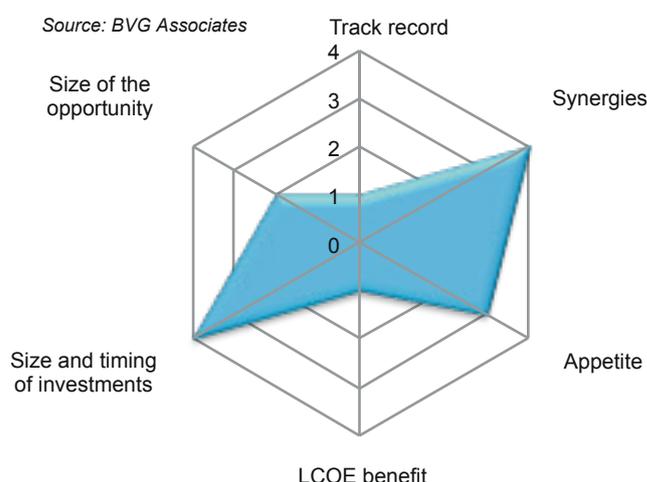
Current suppliers include Seaway Heavy Lifting, Hareema and Scaldis.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Norwegian companies have not installed substation topsides, although lower tier companies have provided equipment and services (see later)
- Synergies are strong as the structures are similar to offshore oil and gas platforms. Semi-submersible deepwater construction vessels are an option for installation activities. Most activity will be in the transport of the structure from construction port to the wind farm. There are very few vessels with the necessary crane capacity to lift substation topsides; DEME, Scaldis and Boskalis are investing in new heavy lift vessels so opportunities are increasingly restricted.
- As the capacity and number of wind farms increases and they move further from shore, so the requirement for substations will increase. The appetite for good installation suppliers will increase accordingly.
- ABB and Aibel have formed a partnership to develop a self-installing gravity base structure for substations. This is based on technology from the oil and gas sector. This innovation provides a good opportunity for LCOE saving, however this will be at the expense of traditional installation contracts.
- Investments by companies can be made incrementally to meet demand
- The size of the opportunity is moderate.

*We have concluded that the opportunity the Norwegian supply chain to enter the sub-station installation market is moderate; the key opportunity is in the transportation of structures from construction port to the wind farm.*

The assessments are summarised in Figure 31.



**Figure 31 Summary of the assessment for substation installation.**

## Installation equipment and support services

This sub-element covers the lower tier activities which are undertaken in support of the primary installation contracts.

Equipment is used during installation includes:

- Cranes for loading components on the quayside
- Sea fastenings and racks for securing components in transit
- Foundation piling equipment such as templates, hammers and handling equipment
- Cable installation equipment such as carousels, tensioners, grapnels, trenching and burial tools, and cable retrieval tools
- Turbine installation equipment such as cranes, yokes and turbine access systems, such as gangways.

Equipment such as cranes and cable handling equipment may be bought by the installation contractor and permanently installed on the vessel or rented from a supplier such as IHC, Menck or Oceanteam. Equipment such as ROVs and support vessels is often rented and in many cases operated by a third party. There are some elements of the installation equipment that are designed and manufactured based on the needs of the specific projects, examples include sea fastening equipment, blade racks and pile handling tools.

The sort of support services required during installation includes:

- Cable route surveys and clearance
- Support vessels such as crew transfer and guard vessels
- Diving
- ROV operations
- Grouting
- Marine operations including vessel modifications, logistics, certification, weather forecasting and planning, and
- Removal of unexploded ordnance.

Many of these services are delivered by small and medium sized companies.

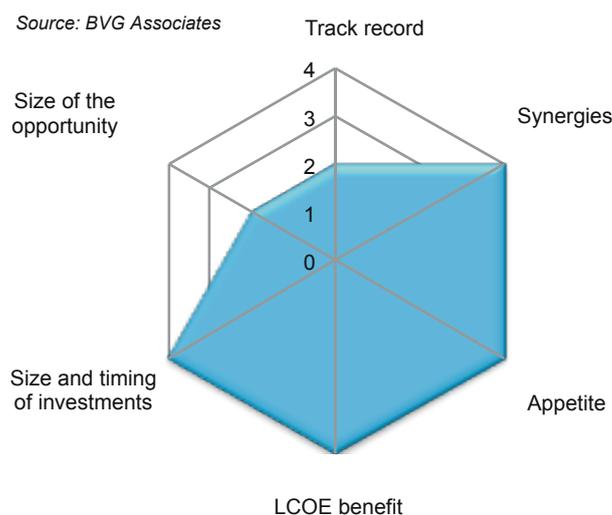
Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Many Norwegian companies have provided installation equipment and services. Notable examples include:
  - Semar which supported with the engineering of the substation loading, transportation and installation for Sheringham Shoal wind farm.
  - Seaproof solutions which provides cable protection solutions
  - ACE Winches and Cranemaster which provide lifting equipment
- Synergies with other subsea engineering activities are high meaning that skills can be readily applied to offshore wind.
- The market is well served with providers of equipment and support services. There is, however, an appetite to explore alternative solutions from parallel industries that can reduce costly vessel use or reduce the weather sensitivity of operations.

- An important challenge is in how to adapt best practice from oil and gas to offshore wind. Innovations that lower piling cost, such as vibro-piling, reduce the weather sensitivity of lifts or reduce the risk of damage to cables during installation will contribute to LCOE savings.
- Investments by companies can usually be made incrementally to meet demand. The primary investments are in product development and in personnel
- The size of the opportunity is moderate.

*We have concluded that installation equipment and support services present a major opportunity for the Norwegian supply chain because overall there are a large number of contracts in the installation equipment and support services sub-element. Many of these will be of relatively small value and suitable for SMEs.*

The assessments are summarised in Figure 32.



**Figure 32 Summary of the assessment for installation and support services.**



## Box 9: Installation equipment and support services



**Company:** Scanmudring AS

**Sub-element:** Installation and commissioning

### Company background:

Scanmudring develops, manufactures and operates advanced subsea heavy machinery. With over three decades experience of operating in the harsh environments of the North Sea and European waters, Scanmudring has honed its expertise giving them the industry insight and technical understanding to develop new pioneering solutions. Since 2000, the company has carried out thousands of hours of subsea operation, in deep water and challenging conditions with restricted access, for major contractors such as Statoil, Shell, BP and ConocoPhillips.

### Task:

Scanmudring is a true specialist and the global leader within an ultra-niche area. The company specialises in dredging, excavation and construction work for the oil, gas and renewable energy industries, providing unparalleled operational expertise and a solutions-orientated approach to complex assignments.

The core business is the removal or relocation of any type of seabed soil or objects close to subsea assets.

Scanmudring's services are as flexible as the challenges the customers face. The company offers everything from comprehensive, full-service solutions performed by their highly skilled offshore personnel, to simple 'plug and play' equipment hire.

### Action:

From their state-of-art workshop, offices and test quay facility in Mandal, South Norway, Scanmudring develops and continually improves a suite of state-of-the-art subsea excavators, called Scanmachines.

The Scanmachines may be used for rock installation not accessible for a rock dumper and is also ideal for relocation of boulders or large and heavy volumes of mass. For fine-tuning and compressing rock dump prior to installation of Gravity based structures, the Scanmachine would offer an efficient method statement to ensure the most stable foundation.

Deployment of the Scanmachine offers a safe alternative to WROV or diver solutions as the equipment can work safely in strong currents and in poor visibility. Operations are highly controlled through the monitoring system, which supports precision work and accurate results, especially when working near subsea assets, or if the work task requires ground leveling or shaping.

The company's strategy for entering and growing presence within the offshore wind sector has involved leveraging existing networks within the oil and gas industry.

### Outcome:

The company has carried out a number of projects within the offshore wind sector and this has allowed the company to build up a unique bank of knowledge regarding the specific challenges of deploying wind assets across a number of different seabed conditions.

Following market entry in 2015, the company has grown its offshore wind activity and it now accounts for around 30 % of total turnover. Since securing its first project with Boskalis for cable installation support, the company has developed a brand that is well known within the offshore wind sector. Client feedback to date has been excellent and this has resulted in Scanmudring expanding its lifecycle offering with customers increasingly asking for input at the pre-planning as well as execution phase of the project.

Scanmudring has found that success in offshore wind correlates with a high level of front-end networking and tendering effort – having a good understanding of upcoming projects and the key stakeholders is imperative. The company has found that successful suppliers are those that ensure a high level of quality and add value to the client at all times.

The company has also found that having a solid track record and proof of concept capability is essential. The demands of operating in offshore wind are high but the recognition of a job well done is at the same time an inspiration to the organization to stay focused and to keep developing new and innovative solutions.



## Onshore works

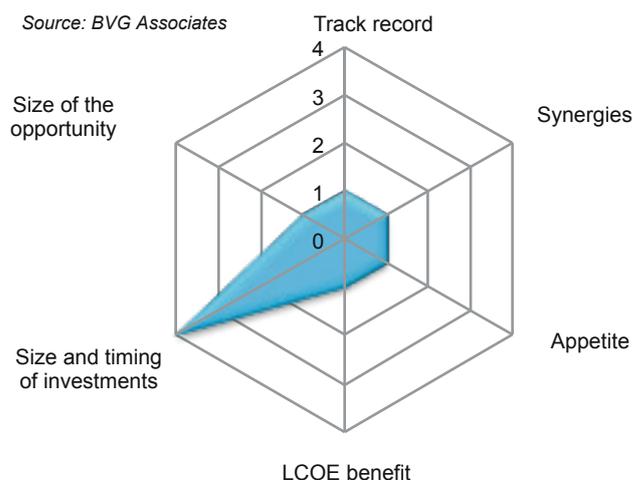
Onshore works include civil engineering and electrical services related to the landfall of the export cable and connection to the grid. Onshore grid connections are managed differently in different jurisdictions.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Very few Norwegian companies have been involved in the provision of onshore works due to the lack of a domestic market and the difficulties in exporting into already well served overseas markets
- Synergies with the Norwegian offshore supply chain are few. Synergies may however exist with the other electricity generation and interconnector sectors.
- The appetite from offshore wind for new suppliers is weak as domestic markets are well served for this activity.
- The opportunities for innovations leading to LCOE savings are limited as this is a relatively straightforward process.
- There is no requirement for significant investment from Norwegian companies wishing to supply this sub-element
- The size of the opportunity is small.

*We have concluded that the opportunity for the Norwegian supply chain to supply onshore works is weak because overall onshore works related to installation and commissioning relies on the supply chain in the local market. This limits opportunities for Norwegian companies because there is no domestic pipeline of projects.*

The assessments are summarised in Figure 33.



**Figure 33 Summary of the assessment for onshore works.**



## 6.6. Operations, maintenance and service

Operation, maintenance and service (OMS) activities make up about 35% of the lifetime spend of an offshore wind farm as shown in Table 6.

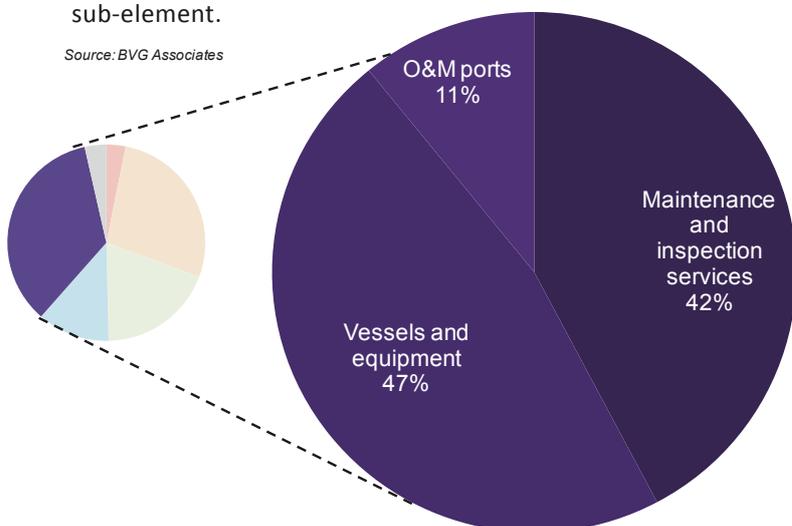
OMS involves providing support during the lifetime of the wind farm to minimise downtime and ensure maximum energy production. Wind farms typically have an operating lifetime of 20 to 25 years. The operation of a wind farm is managed from an onshore base. Typically, wind farm operators will look to use the nearest port that meets its specifications. Activities include day-to-day workflow management and data gathering and analysis. This allows the owners to respond efficiently to failures when they occur and, where possible, to identify potential failures before they occur.

The management of logistics (vessels, helicopters, personnel, specialist tooling and spare parts) is also an important part of the operations role. Maintenance services include both planned and unplanned visits to wind turbines and their foundations to inspect, maintain and repair. In some instances, replacement of large items of plant such as gearboxes or blades is required, which will usually need jack-up vessels such as those used during installation. Vessels and equipment are an essential component of this sub-element and an area where Norwegian suppliers have significant expertise.

Typically, wind turbines are supplied with a five-year service agreement and wind turbine manufacturers provide full turbine maintenance services during this period. Sometimes the service agreement can be for as long as 15 years. At the end of the service agreement, the wind farm owner may negotiate an extension, undertake the wind turbine maintenance itself or contract to a third-party services company.

Figure 34 shows the cost breakdown of the OMS sub-element.

Source: BVG Associates



**Figure 34 Breakdown of operations, maintenance and service sub-element.**

**Table 6 Summary of operations, maintenance and service opportunities.**

| Sub-element                                | Lifetime spend for a 1GW wind farm | Norwegian opportunity |
|--|------------------------------------|-----------------------|
| <b>MAINTENANCE AND INSPECTION SERVICES</b> | 14.8% 8,190 kr million             | Green                 |
| <b>VESSELS AND EQUIPMENT</b>               | 16.4% 9,090 kr million             | Green                 |
| <b>O&amp;M PORTS</b>                       | 3.8% 2,110 kr million              | Red                   |

### Box 10 Norwegian supply chain expertise

Norway has significant expertise across the OMS value chain, including main component suppliers, equipment suppliers and service providers. There are no main contractors based in Norway.

#### Main component suppliers

The main components used in OMS are the vessels, in particular SOVs. Suppliers in Norway like Havyard, Rolls Royce and Ulstein have all designed or manufactured SOVs for the offshore wind market.

#### Equipment suppliers

Norwegian companies are active in supplying equipment in support of OMS. The equipment provided ranges from cranes (Cranemaster and ACE Winches) to work wear (Hansen Protection), and other items such as coatings and air conditioning.

#### Service providers

There are many service providers involved in OMS; Norwegian companies have secured many contracts in this area. Examples include subsea engineering companies such as Argus Remote Systems, Scanmudring and Seløy Undervannsservice. Consultancies include Aqualis Offshore and Force Technology, and multi disciplinary engineering companies such as IKM Group, Global Wind Service and NSG Wind.

## Maintenance and inspection services

Turbine maintenance typically involves a planned visit to each turbine once or twice a year. During these visits, technicians carry out inspection and maintenance activities, including checks on oil and grease levels and a change of filters, checks on instruments, electrical terminations the tightness of bolts, and statutory safety

inspections. Unplanned service involves technician visits to a turbine in response to an alarm reported on the wind farm supervisory control and data acquisition (SCADA) systems or component-specific condition monitoring systems (CMSs). Such visits can entail the simple resetting of a circuit breaker on a piece of auxiliary plant such as a cooling fan, or as serious as replacing the main gearbox or generator following a failure that cannot be repaired offshore.

Foundations for wind turbines and offshore substations require structural inspection and maintenance on a regular basis. The mix of atmospheric, marine and biological corrosion can cause damage that is both expensive and difficult to repair. Inspections map the thickness of the foundations, check seals and corrosion projects, take silt samples and check scour (erosion of the sea bed around the foundations). Inspections can be completed by commercial divers, fixed video cameras or remotely operated vehicles (ROVs) fitted with camera and other remote sensing instruments. Secondary steel structures, for example boat landing systems, ladders and railings, are inspected in addition to the main foundation structure, and these may need regular cleaning of bird guano.

Current suppliers include Global Wind Service, Ziton, Delpro Wind, 3Sun Group, Briggs Marine Contractors and CWind.

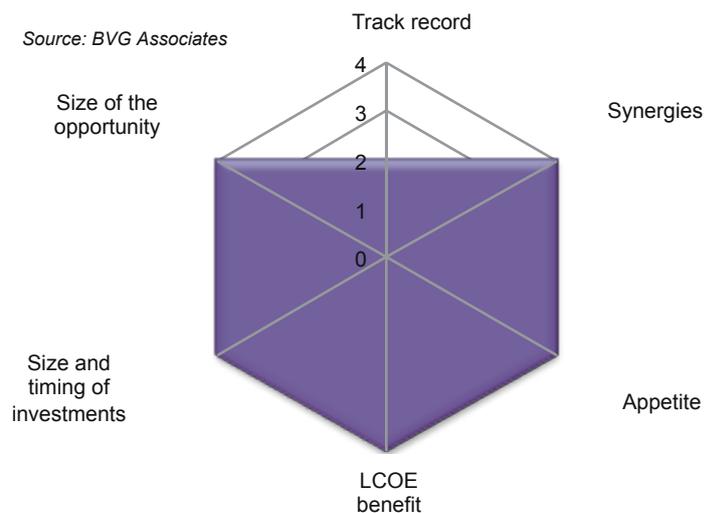
Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- A number of Norwegian companies have been involved in the provision of maintenance and inspection services in offshore wind. This includes cable monitoring (Wirescan) and general subsea work using ROVs.
- Synergies with the Norwegian offshore and maritime supply chain are strong. Norway is home to a number of companies that can support activities as wide ranging as rope access, fire management, remote inspection, monitoring equipment, subsea equipment and related services, cable monitoring, fatigue analysis and corrosion protection.
- These activities are mostly undertaken by the manufacturers while the asset is under warranty, although the cover for balance of plant items may not exceed one year. Post-warranty work may be contracted by the developer or a third party provider. In all cases there is a need for good sub-contractors with maritime experience.
- For the operator to maximise its energy production, it is essential the servicing and repair work is well informed and efficiently delivered. This provides opportunities for innovations from other sectors.
- There is no requirement for significant investment from Norwegian companies wishing to supply this sub-element

- The size of the opportunity is high.

*We have concluded that the provision of maintenance and inspection services presents a major opportunity for the Norwegian supply chain because overall the synergies are very strong with existing activities, there is already a reasonable level of experience in Norway and there is the potential for Norwegian suppliers to make a difference in an area that makes up a big proportion of the overall spend.*

The assessments are summarised in Figure 35.



**Figure 35 Summary of the assessment for maintenance and inspection services.**



## Box 11: Maintenance and inspection services

**Company:** Miros AS

**Sub-element:** Maintenance and inspection services



### **Company background:**

Miros is a privately owned Norwegian technology company established in 1984. It is a world leader in remote sensors and systems measuring the ocean surface, providing reliable wave, current and tidal measurements. The company delivers products and services globally for customers across industries such as offshore oil and gas, shipping, coastal monitoring and offshore wind farms. The company also provides full metocean systems to the same industries.

### **Task:**

Miros observed the predominance of wave-buoys in the offshore wind industry and felt that technology did not fully address the industry needs. Wind farms typically cover large geographical areas with potentially significant sea state variations that are not captured by the point measurement of a buoy. The wind farms are also unmanned, raising concerns of maintenance, repairs and retrieval of water-immersed buoys. Miros has 30 years' experience of providing dry-mounted sensors in harsh weather conditions and minimal maintenance cost. The fact that Miros' sensors produce wave spectra based on area scanning also made them believe that their products and services were well suited for the offshore wind industry. Miros' value proposition was developed to offer wave and current monitoring for asset integrity and marine operations at a lower lifetime cost of ownership and risk with the use of dry mounted, remote sensors.



### **Action:**

Miros started investing in the industry in 2015, by way of moving dedicated sales resources to the industry on a full time basis, with a clear mandate to learn about the industry, be present at every industry event practical, and loop back industry needs to the R&D department on a quick turnaround. Miros also targeted wind park operators with a history in oil and gas, where the brand and existing relationships could help them land their first reference.

### **Outcome:**

Since initially targeting the offshore wind sector, Miros has successfully sold and installed systems at Hywind Pilot, Hywind Scotland, Dudgeon and Humber Gateway. To date, Miros has learned that:

- References from offshore oil & gas do not carry as much weight as expected – initial contract wins take a lot of time and effort
- Bidding has been very focused on capital expenditure – turning the conversation to total cost of ownership can be challenging
- Dedicated resources in sales and product management are a prerequisite for developing proper industry know-how and technical credibility

## Vessels and equipment

Crew transfer vessels (CTVs) typically provide transport for technicians and spares from the onshore base to offshore wind farms less than about 90 minutes transfer time from port. Some wind farms supplement CTVs with full-time helicopter support, for transporting technicians when the task in hand does not require heavy tools or spares, or when sea conditions are severe. Spare parts are stocked in onshore warehouses.

Service operations vessels (SOVs) are larger and more capable than CTVs and are typically used for wind farms more than about 90 minutes transfer time from port. They are effectively a floating OMS base, accommodate between 60 and 90 passengers and contain workshops and storage for equipment, consumables and spares.

Marine coordination activities are required for efficient use of personnel and vessels moving between the onshore base and the offshore wind farm. Weather conditions, visibility and tides are monitored daily in order to coordinate efficiently. It is a 24-hour service.

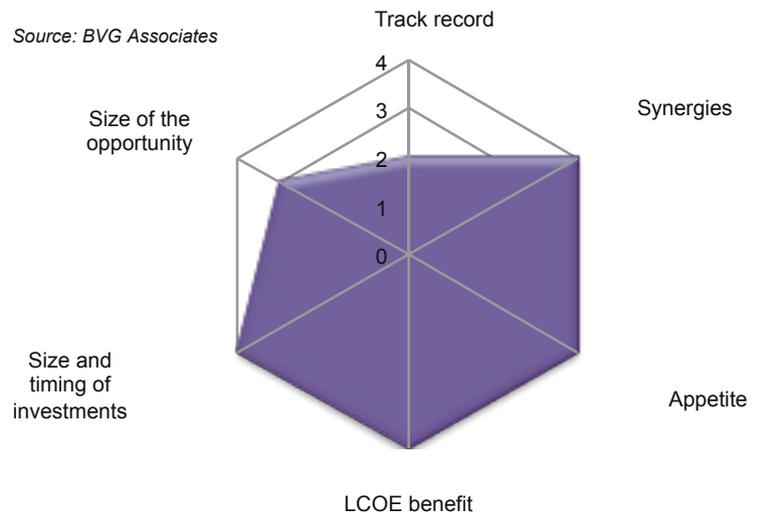
Current CTV suppliers include Bibby Offshore, CWind, Dalby Offshore, Dunston, Rix Sea Shuttle and Seahorse Marine. SOV suppliers include Acta Marine, Bernhard Schulte Shipmanagement and Esvagt.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- A number of Norwegian companies have been involved in the provision of vessels and equipment related to the operations and maintenance of offshore wind farms, which includes design and build of bespoke vessels
- Synergies with the Norwegian offshore and maritime supply chain are strong. Norway is home to a number of shipyards and marine engineering organisations that are well placed to continue to support the growing SOV market. Opportunities for the wider maritime supply chain are also available such as for cranes and winches, logistics support and ship modifications.
- The appetite for new entrants from parallel sectors is strong as the industry moves from frequent CTV visits to walk-to-work-solutions
- There is significant scope for innovation that could reduce LCOE, this is demonstrated by the shift to SOVs for far-from-shore wind farms
- Vessels can be costly items which depending on the specification can require significant investment
- The size of the opportunity is reasonably high.

*We have concluded that the provision of vessels and equipment presents a major opportunity for the Norwegian supply chain because overall the synergies are very strong with existing activities and there is the potential for Norwegian suppliers to make a difference to a high cost area of the wind farm lifecycle.*

The assessments are summarised in Figure 36.



**Figure 36 Summary of the assessment for vessels and equipment.**



## Box 12: Vessels and equipment

**Company:** UPTIME International AS

**Sub-element:** Vessels and equipment

### Company background:

UPTIME was founded in 2011 by Marine Aluminium and ICD. Marine Aluminium is an experienced manufacturer of gangways for the oil and gas industry, with over 100 large gangways sold since 1979. ICD is a respected control systems company, making motion compensation systems since 2000. ICD has supplied a multitude of DP systems, winches, cranes and other handling equipment to customers worldwide.

UPTIME was established to combine the expertise from both companies to create an expert manufacturer of actively compensated gangways for the monohull market, both in oil and gas and offshore wind.

### Task:

The dynamic environment of the offshore wind industry is a challenge for safe walk to work solutions.

With the rate of turbine deployment growing exponentially, the number of crew transfers to offshore wind assets is growing at pace and there is a market need for a safe solution with the capability to operate in as wide a weather window as possible.

UPTIME, through its parent company Marine Aluminium, has developed a market leading position in the supply of safe walk to work systems in the oil and gas industry. Using lessons learned from this sector, the company has been able to develop a product range specifically for the offshore wind sector.

### Action:

UPTIME designed and developed a new 23.4m gangway solution and it has been in use in the wind industry as well as oil and gas since 2013 – the solution is viewed as the benchmark for motion compensated gangways for monohull floatels and workboats within the marketplace.

UPTIME has received order commitment for a total of 29 units of the 23,4m active motion compensated gangway but in addition has an extensive range of products from 6 to 42.5m.

UPTIME gangways have a number of market-leading features. Firstly, the gangways have been designed so that they can be pushed against a platform for short time connections or landed on a landing platform for long term connections – at all times, crew access is available in both directions. Secondly, all UPTIME gangways are available with adjustable height pedestals, making it possible to reach almost any height landing.

By using the full range of UPTIME logistics solutions, customers can take cargo from the vessel warehouse, up through an integrated elevator, and through the UPTIME gangway directly to the transition piece or an offshore structure via an electric trolley. All solutions can be standalone or added-on to additional variants meaning that transfer times and crew utilisation are optimised.

### Outcome:

UPTIME is the market leader for offshore wind walk-to-work systems and the company has been able to take lessons learned from this sector for driving improvement within the oil and gas sector. The push from both markets is helping to develop safer, more efficient and convenient access solutions.

- In the future, multipurpose vessels will be best situated to get charters in a very competitive market. UPTIME is working with its customers to develop capable vessel systems that work well in all markets.



## O&M ports

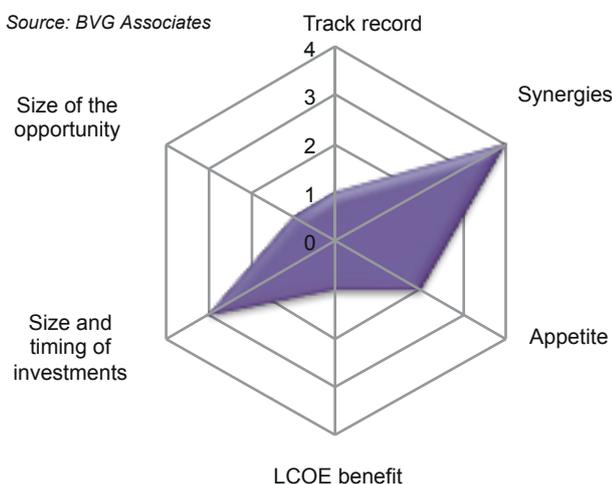
The O&M port is typically the nearest port to the wind farm that meets the required criteria in term of quayside facilities and vessel access. This minimises travelling time and makes the best use of weather windows. The port houses crew areas, offices, warehousing for spare parts and transport vessels.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- Due to the lack of Norwegian projects, there is limited track record for Norwegian ports. There is some experience through NorSea Group’s subsidiary Danbor, which operates ports in Denmark.
- Synergies with port related activities in support of other maritime sectors are high. Suppliers such as helicopter fuelling, communication systems, offshore logistics and training providers may be able to offer their expertise.
- Historically, O&M ports have necessarily been within a short distance to the wind farm. With the move to SOVs, and a few offshore accommodation vessels supporting far-shore installation, this necessity has been reduced. This may allow Norwegian ports to support operations at foreign wind farms.
- The opportunities for innovations leading to LCOE savings are limited
- Existing port infrastructure is mostly capable of supporting operations and maintenance activities. Only small investments will be required
- The size of the opportunity is small.

*We have concluded that O&M ports is a low opportunity because, in spite of the high synergies, there is no pipeline of Norwegian projects for a local O&M port to service.*

The assessments are summarised in Figure 37.



**Figure 37 Summary of the assessment O&M ports.**

## 6.7. Decommissioning

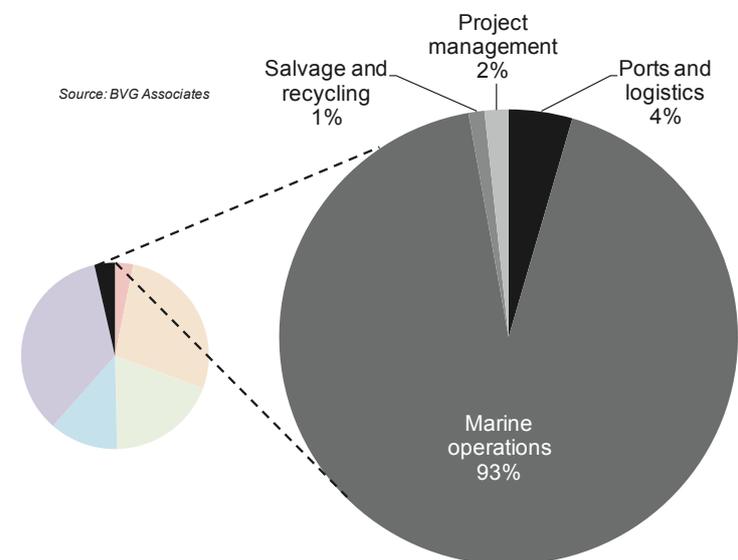
Decommissioning activities make up less than 4% of the lifetime of an offshore wind farm, as shown in Table 7.

Decommissioning involves the removal of the offshore assets after the lifetime of the project. The turbines, transition piece, foundations, offshore substation, meteorological mast, subsea cables and scour protection are all considered for decommissioning. In some instances the site may be repowered with more powerful turbines meaning that some of the assets (for example substation and export cables) can be reused on-site. Consenting bodies typically required that plans for decommissioning are submitted with the planning application. Decommissioning is relatively uncomplicated as you simply reverse the order in which you installed the assets.

Most components will be salvaged and recycled. Currently, there is no established process for recycling the composite materials in blades.

Only small demonstration projects have so far been decommissioned; the 20 to 25 year life of offshore wind farms means that this opportunity won’t be significant before 2030.

Figure 38 shows the cost breakdown of the decommissioning sub-element.



**Figure 38 Breakdown of decommissioning sub-element.**



**Table 7 Summary of decommissioning opportunity.**

| Sub-element                  | Lifetime spend for a 1GW wind farm |                  | Norwegian opportunity |
|------------------------------|------------------------------------|------------------|-----------------------|
| <b>PORTS AND LOGISTICS</b>   | 0.2%                               | 90 kr million    |                       |
| <b>MARINE OPERATIONS</b>     | 3.3%                               | 1,820 kr million |                       |
| <b>SALVAGE AND RECYCLING</b> | 0.0%                               | 20 kr million    |                       |
| <b>PROJECT MANAGEMENT</b>    | 0.1%                               | 30 kr million    |                       |

## Ports and logistics

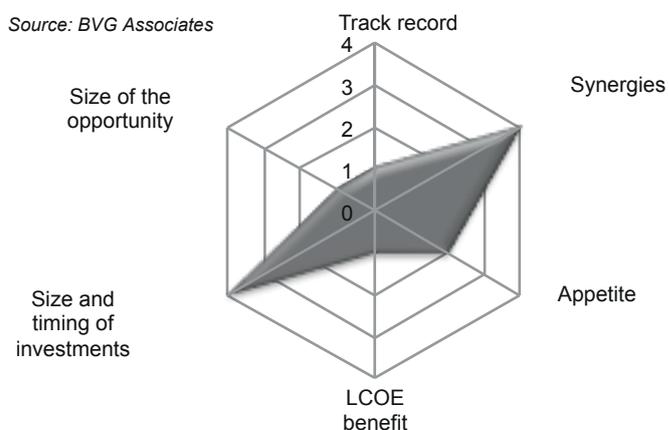
The ports and logistics requirements are much the same as in the installation and commissioning phase, with the added need for salvage infrastructure.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- There is no track record as decommissioning has not occurred to date for commercial wind farms
- Norway’s existing offshore supply chain has a number of ports capable of supporting the vessels required which are much the same as those used in installation and commissioning
- Installation ports may be reused as decommissioning ports. It is possible that some ports will develop specific infrastructure for decommissioning, particularly if offshore wind installation ports remain busy or have switched to other sectors.
- Innovations in port operations transferred from the existing offshore supply chain will only have a small impact on LCOE
- Significant investment in infrastructure would not be required for Norwegian ports and logistics companies to enter the market
- The size of the opportunity is small.

*We have concluded that decommissioning ports and logistics presents a moderate opportunity for the Norwegian supply chain because overall the synergies are very strong with existing activities.*

The assessments are summarised in Figure 39.



**Figure 39 Summary of the assessment for ports and logistics.**

## Marine operations

The use of large decommissioning vessels significantly increases cost therefore the bulk of the breaking work will be done onshore. Marine operations take into account the time and costs involved in the decommissioning processes and define the most efficient solution.

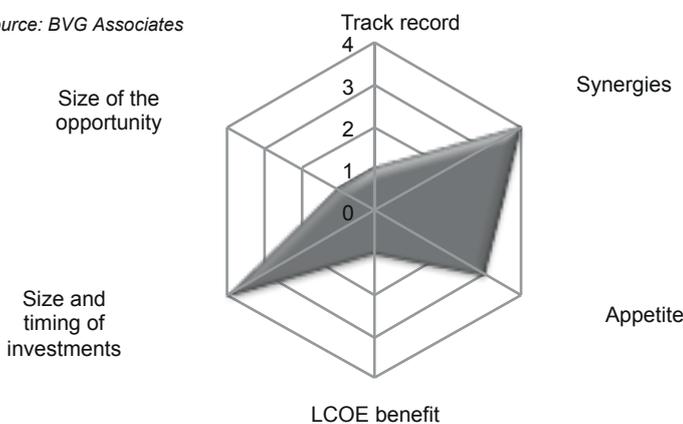
Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- There is no track record as little decommissioning has occurred to date for commercial wind farms
- There are strong synergies with Norway’s existing offshore supply chain which is experienced in performing marine operations in hostile environments
- It is anticipated that companies who provide marine operations in other areas of the offshore wind life cycle will also provide the decommissioning support
- Innovations in marine operations transferred from the existing offshore supply chain will only have a small impact on LCOE
- Decommissioning is likely to involve similar vessels to those used in installation. For Norwegian suppliers that have been involved in installation, little new investment will be required.
- The size of the opportunity is small.

*We have concluded that marine operations in decommissioning presents a moderate opportunity for the Norwegian supply chain because overall the synergies are very strong with existing activities and Norway will be able to build on its strong maritime background.*

The assessments are summarised in Figure 40.

Source: BVG Associates



**Figure 40 Summary of the assessment for marine operations.**

## Salvage and recycling

Salvage and recycling covers what should be done with the structures once they arrive onshore. The structures will be disassembled into their component materials and then processed. Reuse is the preferred option, followed by recycling. Disposal is the last option considered. Reuse may be an option for gearboxes and generators, which may be refurbished as spares for operating wind farms. Most other metallic components will be recycled.

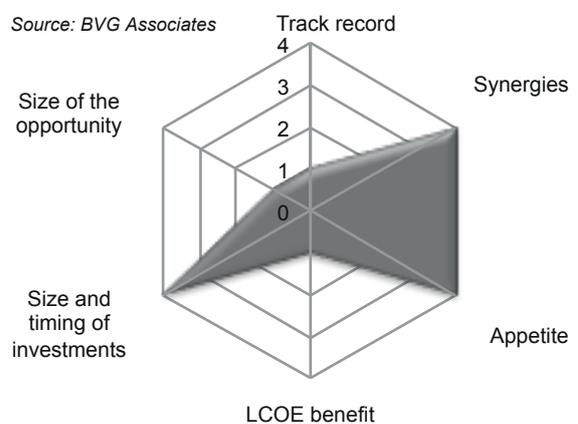
Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- There is no track record as decommissioning has not occurred to date for commercial wind farms
- There are strong synergies with Norway’s existing offshore supply chain which is experienced in decommissioning offshore structures
- There will be a strong appetite from the sector for good suppliers due to the strict regulations which insist that the site is left in a similar condition as before the project
- The potential for LCOE impact is low because of the small lifetime spend in this sub-element
- Significant investment will not be required for Norwegian suppliers to support salvage and recycling
- The size of the opportunity is small.

*We have concluded that salvage and recycling presents a moderate opportunity for the Norwegian supply chain because overall the synergies are very strong with existing activities.*

The assessments are summarised in Figure 41.

Source: BVG Associates



**Figure 41 Summary of the assessment for salvage and recycling.**



## Project management

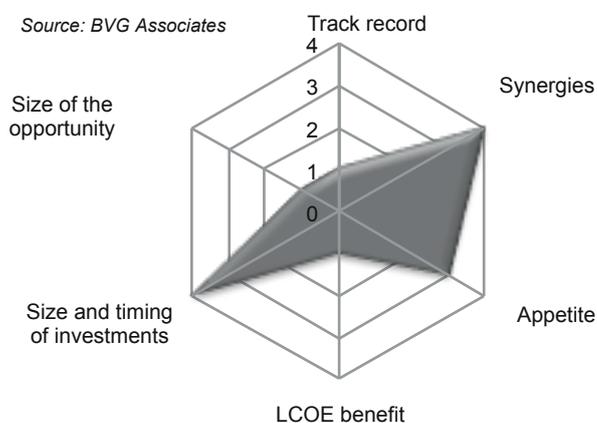
The decommissioning schedule will be unique to each wind farm and depend on the specific mix of assets installed. Planning the safe disposal of such a large number of individual offshore assets is challenging and should be considered early in the design stage of the project. Legislation and regulations around decommissioning is likely to vary from country to country and will require local knowledge.

Our observations on the Norwegian supply chain in this area, based on the assessment criteria, are:

- There is no track record as decommissioning has not occurred to date for commercial wind farms
- There are strong synergies with Norway's existing offshore supply chain which is experienced in decommissioning offshore structures
- Companies who provide project management support in offshore wind development can also provide the decommissioning support
- The potential for LCOE impact is low because of the small lifetime spend in this sub-element
- Significant investment will not be required for Norwegian suppliers to support this sub-element
- The size of the opportunity is small.

*We have concluded that decommissioning project management presents a moderate opportunity for the Norwegian supply chain because overall there are strong synergies with existing activities.*

The assessments are summarised in Figure 42



**Figure 42 Summary of the assessment for project management.**

# 7. Strategies for market entry

## 7.1. Market characteristics

As the offshore wind sector has matured, it has developed unique requirements. It is important for suppliers looking to enter the market to understand these nuances and prepare accordingly. Some of the key characteristics of the offshore wind market are highlighted in Table 8.

**Table 8 Notable market characteristics.**

| Differences                        | Offshore wind market characteristics   |
|------------------------------------|--|
| <b>VOLUME AND NATURE OF SUPPLY</b> | High numerical demand for standardised goods and services  |
| <b>SUBSIDIES</b>                   | Direct price support often from national governments   |
| <b>CULTURE</b>                     | Innovation at pace in an environment with technical unknowns   |
| <b>VALUE</b>                       | Achieved through intellectual property ownership   |
| <b>CONTRACTING</b>                 | Less established processes and potentially adversarial procurement in nature to achieve cost reduction |

## 7.2. Capabilities required in offshore wind

It is important for any suppliers considering diversification into the offshore wind sector to have not only the technical capability to supply but also to have the correct approach to the industry.

Cost is a key driving factor in the industry. The competitive nature of winning the rights to build projects and sell the electricity means that developers, combined with pressure from governments to eliminate subsidies are seeking to reduce costs throughout the supply chain. In order to maintain good margins it is important for suppliers to standardise their products so that they can be used across multiple wind farms.

Innovation is another key tool in reducing costs. This presents opportunities for forward-thinking suppliers from parallel sectors to transfer proven solutions that can solve common problems.

A commercial offshore wind farm may have 100 turbines spread across 100km<sup>2</sup>. It is therefore to a supplier's advantage if they can carry out multiple operations efficiently. Installation and operations contractors must be able to repeat high-risk operations over a large geographical area.

## 7.3. Challenges to entry

New entrants need to understand the challenges they may face in entering the offshore wind market and seek to mitigate where possible.

### Lack of track record

Gaining a credible track record can be a challenge for new entrants to the offshore wind sector. The industry emerged in Europe 25 years ago and in order to compete with more experienced players, companies must focus on demonstrating technical, commercial and logistical experience in offshore operations applicable to wind. Partnerships with existing offshore wind suppliers can help establish credibility and are often an effective way to enter the sector.

### Risk-averse investors

Early offshore wind farms were mostly balance-sheet financed by big utilities. As projects get bigger and more complex, third party project finance is becoming more prevalent. This type of support may involve institutions that are relatively risk-averse meaning that displacing incumbent suppliers with a track record can be difficult. New suppliers should therefore aim to mitigate this by ensuring that goods and services offered to offshore wind are approved and qualified to a recognised standard.

### Cost competitiveness

It is important when tendering that companies new to the sector highlight their value proposition to offshore wind, making clear their costs and value-add capabilities. Suppliers should aim to price competitively by demonstrating learning and standardisation improvements in tenders and seek to recover margins via higher volume economies of scale where applicable.

### Fixed price contracts

Offshore wind projects require suppliers to adhere to fixed budgets and delivery schedules. New suppliers must demonstrate an ability to work consistently under such conditions.

- Offshore wind CAPEX contracts are typically lump sum fixed price contracts where the level of supplier contingency is negotiated
- Offshore wind developers often expect long warranty periods on capital and installation spend and OPEX contracts are often linked to asset uptime
- Oil and gas contracts can include incentives to deliver early or under budget but this practice is not yet fully established in offshore wind.



## 7.4. Conclusions

The offshore wind sector presents Norwegian suppliers with an exciting new opportunity and access to a business stream that is growing. By serving multiple markets, suppliers can spread their risk profile and mitigate some of the uncertainties in other markets they serve.

**New entrants from oil and gas manufacturers focusing on the capital phase should target multiple projects and seek out framework opportunities.** Offshore wind is capital intensive and CAPEX is concentrated on a short period of the lifecycle.

**Operational spend 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.** Oil and gas suppliers in particular have a track record of servicing assets in harsh offshore environments and as a consequence there are abundant diversification opportunities.

**Suppliers need to offer prospective customers cost-competitive or innovative solutions to displace the existing supply chain.** Offshore wind faces the challenge of deploying large reliable assets far from shore while reducing costs. A strong and competent supply chain has grown to support the offshore wind industry. In areas such as project management, installation and OMS, however, the synergies between offshore wind and the Norwegian offshore supply chain are high and offshore wind can benefit from the skills in Norway.

**Norwegian suppliers must be aware of the differences within the sector and plan a market entry strategy accordingly.** New suppliers must demonstrate to offshore wind customers that they can bring significant value-add to the sector and they must convey a message of long-term commitment and support of the sector.

# Appendix A: Market briefings

The following pages present market briefings on the key European markets for offshore wind. An additional market briefing is included for Europe as a whole.

These markets are:

- Belgium
- Denmark
- France
- Germany
- Netherlands
- UK



# European market overview

## Market growth

At the end of 2016, Europe had 13.0GW of installed capacity. This is anticipated to reach 43.8GW by 2025.

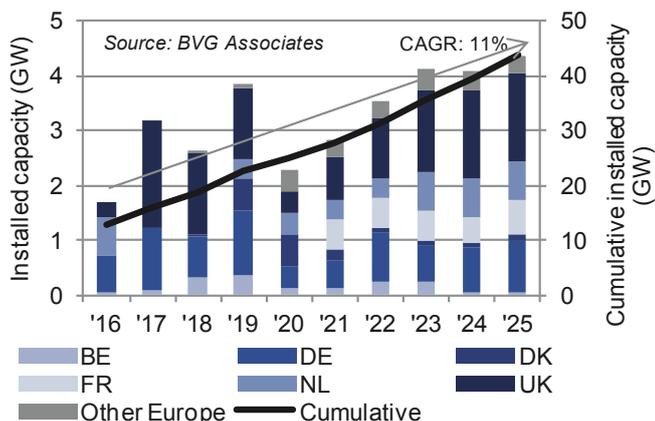


Figure 1 Forecast installed capacity with compound annual growth rate (CAGR).<sup>1</sup>

## Owners

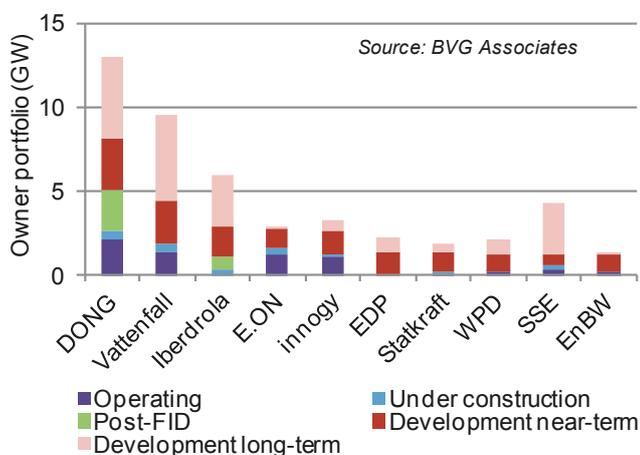


Figure 2 Top 10 owner portfolios across Europe.<sup>2</sup>

Table 1 Top 10 owner active markets.<sup>3</sup>

|                       |   |   |   |   |   |   |
|-----------------------|---|---|---|---|---|---|
| DONG                  | X | ✓ | ✓ | X | ✓ | ✓ |
| VATTENFALL            | X | ✓ | ✓ | X | ✓ | ✓ |
| IBERDOLA <sup>4</sup> | X | ✓ | X | ✓ | X | ✓ |
| E.ON                  | X | ✓ | ✓ | X | X | ✓ |
| INNOGY                | ✓ | ✓ | X | X | X | ✓ |
| EDP                   | X | X | X | ✓ | X | ✓ |
| STATKRAFT             | X | X | X | X | X | ✓ |
| WPD                   | X | ✓ | X | ✓ | X | X |
| SSE                   | X | X | X | X | X | ✓ |
| ENBW                  | X | ✓ | X | X | X | X |

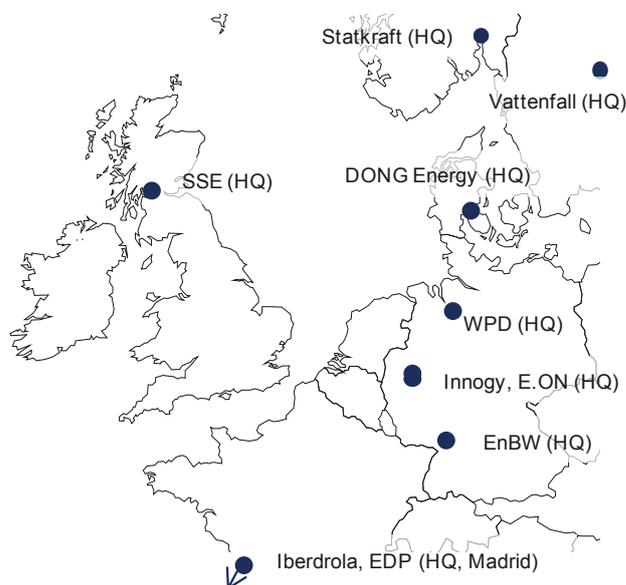


Figure 3 Owner headquarters.<sup>5</sup>

1 P50 forecast, P50 'best guess' means there is a 50% chance that forecast will be exceeded.

2 Owners are ranked based on their portfolio size from projects in operation to development near-term. Near term are projects currently in development anticipated to have year of first turbine installation before the end of 2025.

3 Owner has a share in at least one project in given country.

4 Including ScottishPower Renewables

5 Some owners have country specific offices which are not shown.

## Suppliers

Active markets are considered those where the supplier has been contracted on at least one project in a given country with first turbine installation in 2010 or after.

### Turbine supply

Table 2 Main turbine supplier active markets.

|   | Supplier   | BE | DE | DK | FR | NL | UK |
|---|------------|----|----|----|----|----|----|
| ● | ADWEN      | X  | ✓  | X  | ✓  | X  | X  |
| ● | GE/ALSTOM  | ✓  | ✓  | X  | ✓  | X  | X  |
| ● | MHI VESTAS | ✓  | ✓  | ✓  | X  | ✓  | ✓  |
| ● | SENVION    | ✓  | ✓  | X  | ✓  | X  | ✓  |
| ● | SIEMENS    | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |

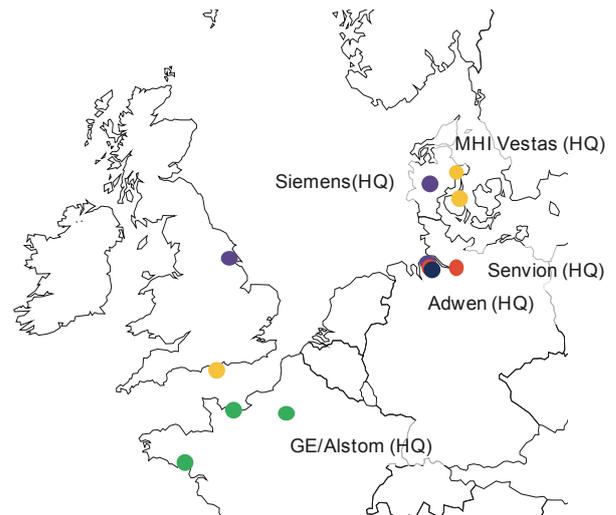


Figure 4 Main turbine supplier headquarters and main manufacturing locations.

### Foundation supply

Table 3 Main foundation supplier active markets.

|   | Supplier         | BE | DE | DK | FR | NL | UK |
|---|------------------|----|----|----|----|----|----|
| ● | AMBAU            | X  | ✓  | X  | X  | X  | X  |
| ● | BIFAB            | X  | ✓  | X  | X  | X  | ✓  |
| ● | BLADT INDUSTRIES | X  | ✓  | X  | X  | X  | ✓  |
| ● | EEW              | ✓  | ✓  | X  | X  | ✓  | ✓  |
| ● | SIF GROUP        | ✓  | ✓  | ✓  | X  | ✓  | ✓  |
| ● | SMULDERS         | ✓  | X  | X  | ✓  | X  | ✓  |
| ● | STEELWIND        | X  | ✓  | X  | X  | X  | ✓  |

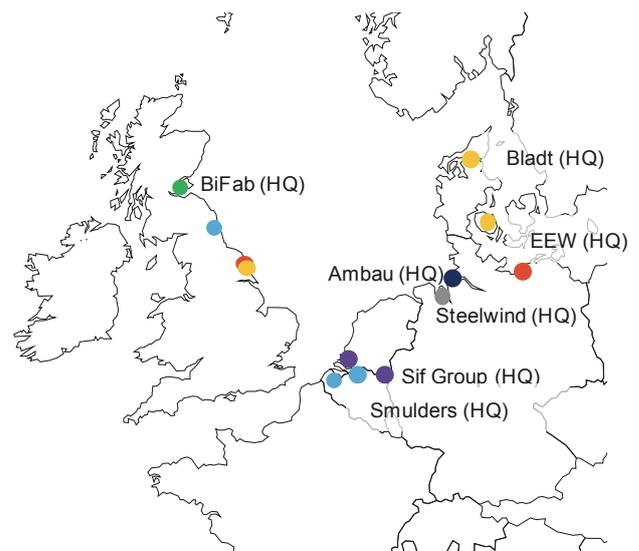


Figure 5 Main foundation supplier headquarters and main manufacturing locations.



## Array and export cable supply

Table 4 Main array and export cable supplier active markets.

|   | Supplier   | BE | DE | DK | FR | NL | UK |
|---|------------|----|----|----|----|----|----|
| ● | JDR        | ✓  | ✓  | ✗  | ✗  | ✗  | ✓  |
| ● | NEXANS     | ✓  | ✓  | ✓  | ✗  | ✗  | ✓  |
| ● | NKT CABLES | ✗  | ✓  | ✓  | ✗  | ✓  | ✓  |
| ● | NSW        | ✗  | ✓  | ✓  | ✗  | ✓  | ✓  |
| ● | PRYSMIAN   | ✓  | ✓  | ✗  | ✗  | ✓  | ✓  |

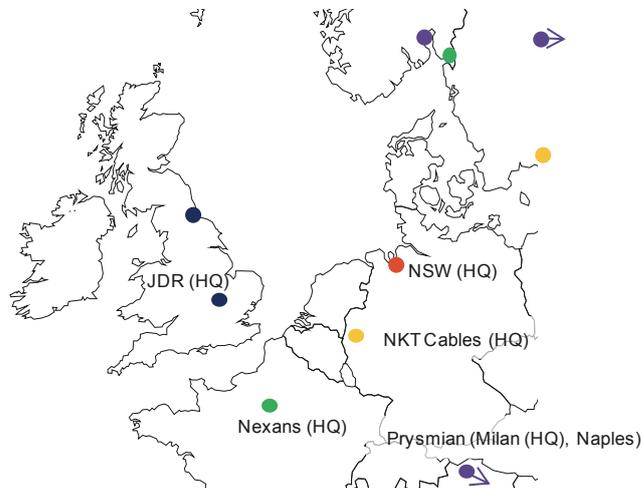


Figure 6 Array and export cable supplier headquarters and main manufacturing locations.

## Offshore substation topside supply

Table 5 Main offshore substation topside supplier active markets.

|   | Supplier         | BE | DE | DK | FR | NL | UK |
|---|------------------|----|----|----|----|----|----|
| ● | BABCOCK          | ✗  | ✗  | ✗  | ✗  | ✗  | ✓  |
| ● | BLADT INDUSTRIES | ✗  | ✓  | ✓  | ✗  | ✗  | ✓  |
| ● | ENGIE FABRICOM   | ✓  | ✓  | ✗  | ✗  | ✓  | ✓  |
| ● | HARLAND & WOLFF  | ✗  | ✓  | ✗  | ✗  | ✗  | ✓  |
| ● | HEEREMA          | ✗  | ✗  | ✗  | ✗  | ✗  | ✓  |
| ● | HOLLANDIA        | ✗  | ✓  | ✓  | ✗  | ✗  | ✗  |
| ● | HSM OFFSHORE     | ✓  | ✗  | ✓  | ✗  | ✗  | ✗  |
| ● | SEMBMARINE SLP   | ✗  | ✗  | ✗  | ✗  | ✗  | ✓  |
| ● | STX FRANCE       | ✓  | ✓  | ✗  | ✗  | ✗  | ✓  |

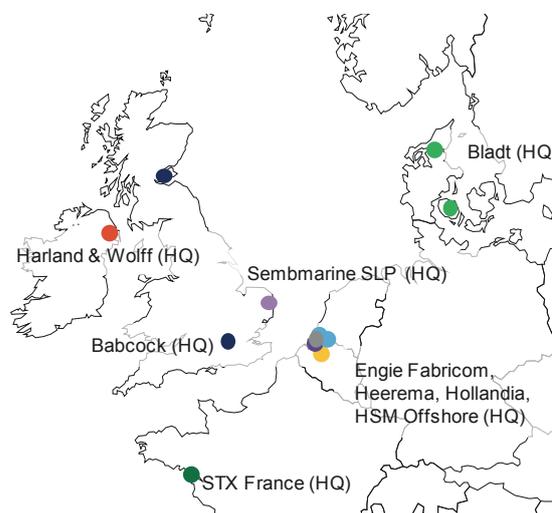


Figure 7 Main offshore substation topside supplier headquarters and main manufacturing locations.

## Offshore substation electrical supply

Table 6 Main offshore substation electrical supplier active markets.

|   | Supplier           | BE | DE | DK | FR | NL | UK |
|---|--------------------|----|----|----|----|----|----|
| ● | ABB                | ✓  | ✗  | ✗  | ✗  | ✗  | ✓  |
| ● | CG POWER SOLUTIONS | ✓  | ✓  | ✗  | ✗  | ✓  | ✓  |
| ● | GE GRID SOLUTIONS  | ✗  | ✓  | ✗  | ✗  | ✗  | ✓  |
| ● | SIEMENS T&D        | ✗  | ✓  | ✓  | ✗  | ✗  | ✓  |

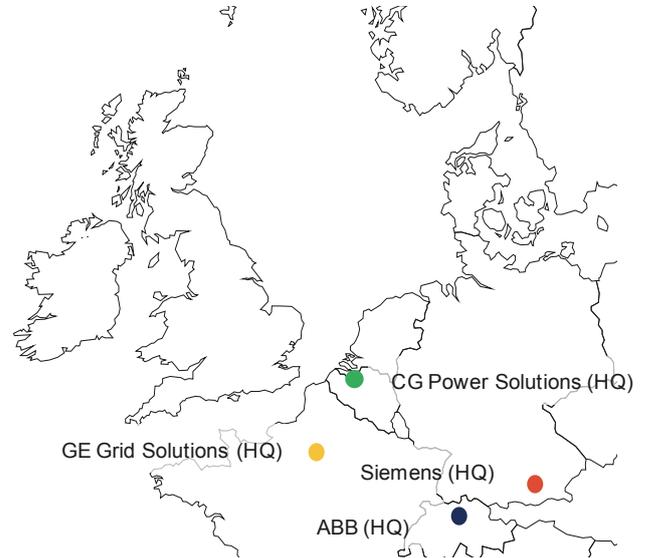


Figure 8 Main offshore substation electrical supplier headquarters.

## Turbine and foundation installation supply

Table 7 Main turbine and foundation installation supplier active markets.

|   | Supplier         | BE | DE | DK | FR | NL | UK |
|---|------------------|----|----|----|----|----|----|
| ● | A2SEA            | ✗  | ✓  | ✓  | ✗  | ✗  | ✓  |
| ● | BOSKALIS         | ✗  | ✗  | ✗  | ✗  | ✗  | ✓  |
| ● | FRED OLSEN       | ✗  | ✓  | ✗  | ✗  | ✗  | ✓  |
| ● | GEOSEA           | ✓  | ✓  | ✗  | ✗  | ✗  | ✓  |
| ● | JAN DE NUL       | ✓  | ✗  | ✗  | ✗  | ✗  | ✓  |
| ● | MPI OFFSHORE     | ✓  | ✓  | ✗  | ✗  | ✗  | ✓  |
| ● | SEAJACKSE        | ✗  | ✓  | ✗  | ✗  | ✗  | ✓  |
| ● | SWIRE BLUE OCEAN | ✗  | ✓  | ✗  | ✗  | ✗  | ✓  |
| ● | VAN OORD         | ✓  | ✓  | ✓  | ✗  | ✓  | ✓  |

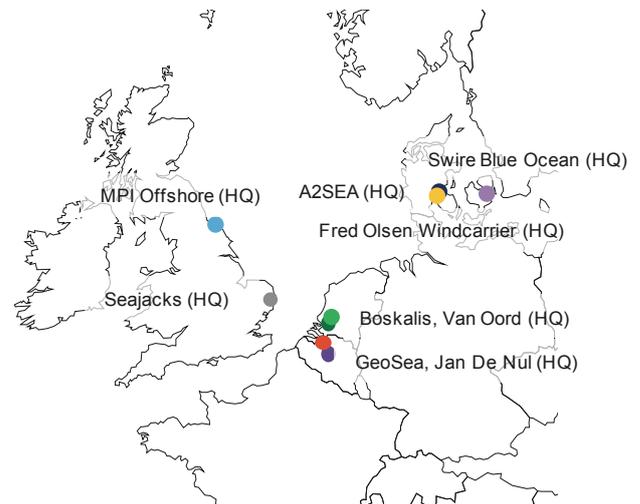


Figure 9 Main turbine and foundation installation supplier headquarters.



## Array and export cable installation supply

Table 8 Main array and export cable installation supplier active markets.

|   | Supplier      | BE | DE | DK | FR | NL | UK |
|---|---------------|----|----|----|----|----|----|
| ● | DEEPOCEAN     | ✓  | ✓  | X  | X  | X  | ✓  |
| ● | FUGRO         | X  | X  | X  | X  | X  | ✓  |
| ● | JAN DE NUL    | ✓  | X  | X  | X  | X  | ✓  |
| ● | NEXANS        | ✓  | ✓  | X  | X  | X  | ✓  |
| ● | NSW           | X  | ✓  | ✓  | X  | X  | ✓  |
| ● | PRYSMIAN      | X  | ✓  | X  | X  | X  | X  |
| ● | SIEM OFFSHORE | X  | ✓  | X  | X  | X  | ✓  |
| ● | TIDEWAY       | ✓  | X  | X  | X  | X  | ✓  |
| ● | VAN OORD      | ✓  | X  | X  | X  | X  | ✓  |
| ● | VBMS          | ✓  | ✓  | ✓  | X  | ✓  | ✓  |

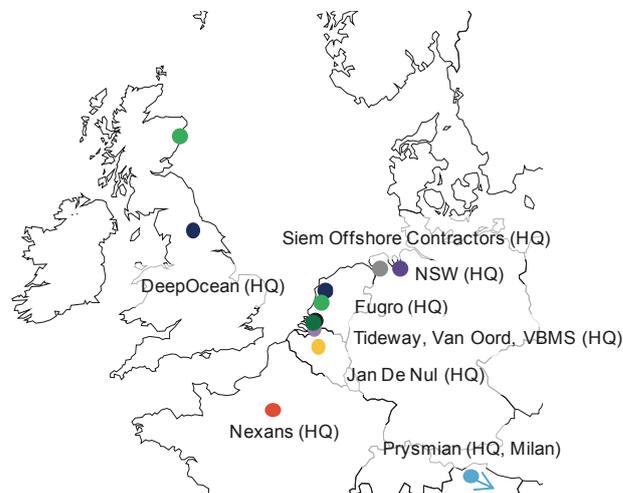


Figure 10 Main array and export cable installation supplier headquarters.

## Offshore substation installation supply

Table 9 Main offshore substation installation supplier active markets.

|   | Supplier             | BE | DE | DK | FR | NL | UK |
|---|----------------------|----|----|----|----|----|----|
| ● | HEEREMA              | X  | ✓  | X  | X  | X  | X  |
| ● | MPI OFFSHORE         | X  | X  | X  | X  | X  | ✓  |
| ● | SCALDIS              | ✓  | ✓  | ✓  | X  | ✓  | ✓  |
| ● | SEAWAY HEAVY LIFTING | X  | ✓  | ✓  | X  | X  | ✓  |

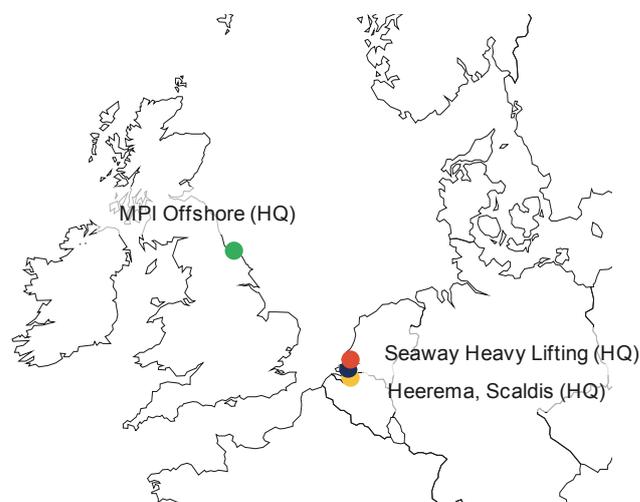


Figure 11 Main offshore substation installation supplier headquarters.

# Belgium

## Market growth

At the end of 2016, Belgium had 0.8GW of installed capacity. This is anticipated to reach 2.4GW by 2025.

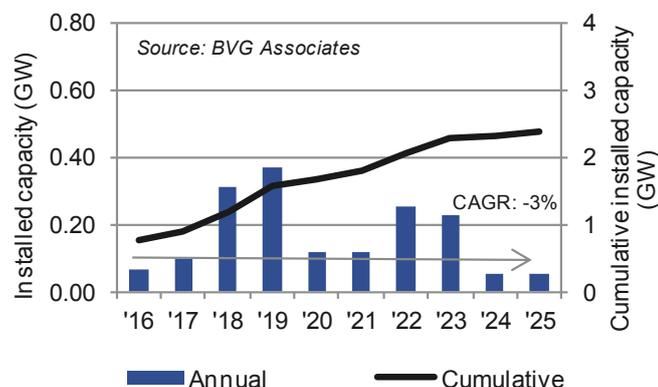


Figure 1 Forecast installed capacity with compound annual growth rate (CAGR).<sup>1</sup>

## Regulation

The **Belgische Ministers van Energie (Belgian Energy Ministers)** of the **Belgische Federale Overheid (Belgian Federal Government)** issue leases for offshore wind projects. Existing operational projects have leases for 20 years. For projects not yet constructed, leases are awarded for 20 years (although likely to be extended to 22 years).

Developers of offshore wind farms need the following licences:

1. Offshore domain concession.  
Between 2004 and 2010 nine offshore domain concessions were awarded to developers. An environmental permit is not guaranteed with the award of the concession and the developer must still develop the site and complete environmental surveys and studies. The Belgian Energy Ministers grant or refuse environmental permit applications
2. Marine protection construction authorisation and operating licence
3. Export cable licence
4. Onshore cable licence (depending on the onshore cable route).

<sup>1</sup> P50 forecast, P50 'best guess' means there is a 50% chance that forecast will be exceeded.

For projects installed before 2014, a feed-in tariff was the subsidy mechanism, granted by the federal energy regulator **Commissie voor de Regulering van de Elektriciteit en het Gas (CREG)**. A renewable energy certificate (REC) was granted for every MWh produced. RECs had a minimum guaranteed price of €107 for the first 216MW and €90 for capacity exceeding 216MW.

The subsidy mechanism for projects constructed from 2014 is a contract for difference (CfD). The CfD is awarded at a fixed price of €138/MWh (although it is likely the Government will reassess the fixed price offered for new projects every three years).

**Elia** is the transmission system operator (TSO). To date, offshore wind farms have been connected to the grid on a project-by-project basis with the developer paying two-thirds of the supply and install cost, and Elia paying one-third. As a result of political objections to this, Elia is currently consulting with stakeholders for the development of a Belgian offshore grid, to provide high voltage transmission for several offshore wind farms.

## Organisations

**Agoria Renewable Energy Club** is an industry association. It plays an important role in knowledge transfer in the supply chain and supports members to win business opportunities abroad.

**Flanders Maritime Cluster** is an industry association for the marine and maritime industry in Flanders. It organises industry events and conducts research projects.

## Owners

**Otary** is a partnership of eight Belgium companies including: Elicio, Rent-a-Port, DEME, SRIW Environment, Aspiravi, Z-kracht, Power@Sea and Socofe. It wholly owns the Rentel and Seastar projects and has shares in the Mermaid project.

**Innogy** is an energy utility headquartered in Germany. It wholly owns the operating Thornton Bank one and two and has shares in Thornton Bank three.

**Elicio** is a specialist developer headquartered in Belgium. It has 50% share in the Norther project.

**Belwind** is a public company headquartered in Belgium. It owns the operational Belwind project.

**Parkwind** is a specialist developer headquartered in Belgium. Its three shareholders are Colruyt Group, Korys and PMV. It has shares in the operating Northwind project and Nobelwind which is under construction.

**Sumitomo Corporation** is a trading house headquartered in Japan. It has shares in the operating Northwind project and Nobelwind which is under construction.



**TTR Energy** is a renewable energy investment company headquartered in Belgium. It has shares in the Northwester two project currently under development.

**Mitsubishi DGE** is a subsidiary of Mitsubishi Corporation, which has European headquarters in the UK. It has shares in the Norther project.

**Eneco** is an independent energy company, headquartered in the Netherlands. It has shares in the Norther project.

**Aspiravi** is a specialist developer headquartered in Belgium. It has shares in the Northwind project. It is also an equal shareholder in Otary, with seven other Belgium companies.

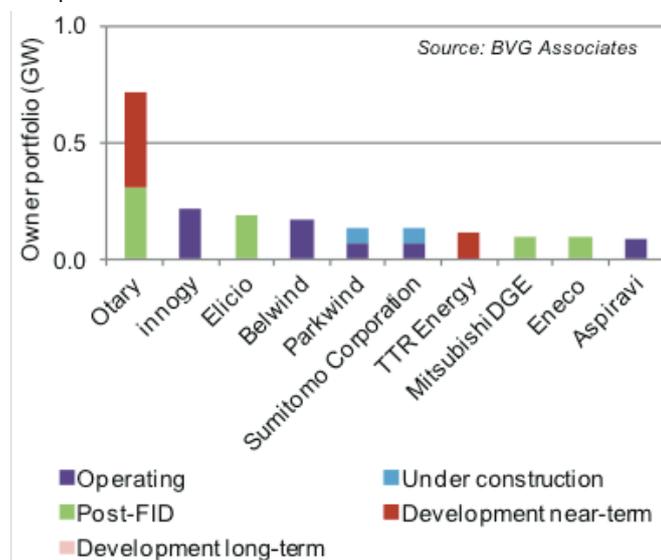


Figure 2 Top 10 owner portfolios.<sup>2</sup>

## Suppliers<sup>3</sup>

### Turbine supply

**MHI Vestas Offshore Wind** is a supplier of offshore wind turbines and is a joint venture formed in April 2014 between Mitsubishi Heavy Industries (MHI) and Vestas. It secured contracts to supply the Nobelwind and Norther projects.

<sup>2</sup> Owners are ranked based on their portfolio size from projects in operation to development near-term. Near term are projects currently in development anticipated to have year of first turbine installation before the end of 2025.

<sup>3</sup> Suppliers are a selection of those who have headquarters in the country or have been contracted on projects with year of first turbine installation in 2016 or after.

### Foundation supply

**Bladt Industries** is a Danish manufacturer of offshore steel structures. Its primary activities in the offshore wind industry are the manufacture of steel foundations and assembly of substation jackets and topsides. Bladt has recently supplied the substation topside to the Nobelwind offshore wind farm.

**EEW Special Pipe Constructions (EEW)** is a German manufacturer of steel tubular structures. EEW is involved in the production of monopile foundations, and tubulars and pin piles for jacket foundations. EEW recently supplied 51 monopile foundations to the Nobelwind wind farm.

### Array and export cable supply

**Nexans** is a French supplier of power and communication cables. In the offshore wind industry, it is involved in supply and installation of array and export cables, including export cable supply to Nobelwind.

**Prysmian** is a supplier of power and communication cables with an Italian headquarters. Its focus in the offshore wind industry is the supply and installation of array and export cables. Prysmian is the array cable supplier to the Nobelwind and Rentel wind farms.

### Offshore substation topside supply

**STX France Solutions** is a French shipbuilder and fabricator of large offshore structures. It is primarily involved in the design and assembly of HVAC offshore substation topsides and jackets. It is also seeking to enter the turbine foundation market. STX France will supply substation topside for the Rentel offshore wind farm.

### Offshore substation electrical supply

**Semco Maritime (Semco)** is a Danish project engineering contractor. Its primary activity in the offshore wind industry is the design and project management of the high voltage electrical systems and was the Nobelwind substation electrical supplier.

### Turbine and foundation installation

**Jan De Nul** is a dredging and marine contractor. Its primary activities in the offshore wind industry are the installation of turbine, foundations and array and export cables and the manufacture of concrete gravity base foundations. Jan De Nul supplied turbine, foundation and export cable installation services to the Nobelwind wind farm.

**GeoSea** is a Belgian marine construction company, part of the DEME Group. Its primary activity in the offshore wind industry is the installation of foundations and turbines. It installed turbines on Thornton Bank One, Two and Three and foundation installation for Northwind wind farm.

# Germany

## Market growth

At the end of 2016, Germany had 4.1GW of installed capacity. This is anticipated to reach 10.0GW by 2025.

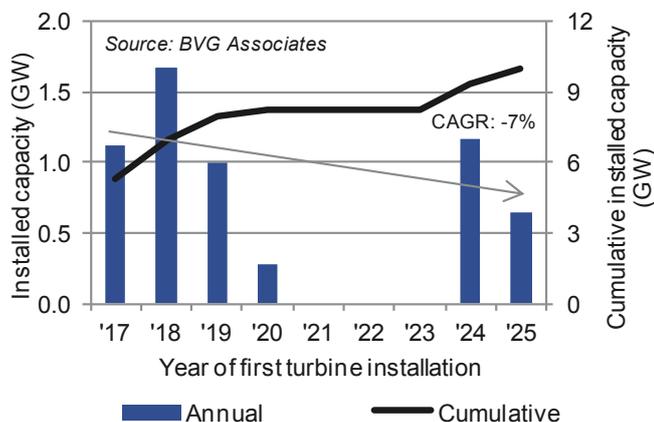


Figure 1 Forecast cumulative installed capacity with compound annual growth rate (CAGR).<sup>1</sup>

## Regulation

The Germany market regulation is changing with the introduction of the Offshore Wind Act (“WindSeeG”) which became law on 1 January 2017. Previously, leasing for offshore wind sites located within the German Exclusive Economic Zone was managed by **BSH (Federal Maritime and Hydrographic Agency)**. Developers of wind farms completed the environmental impact assessment and associated development activities. The BSH examined consent applications through consultation with the **Waterways and Shipping Directorate-General** and the relevant German coastal state (for the approval of the wind farm transmission cables). Leases were granted for 25 years. The previous support mechanism was through a feed-in tariff, which the generator received per megawatt hour produced for the lifetime of the contract.

The WindSeeG introduces a centralised planning approach, which involves an Area Development Plan and a new contract for difference (CfD) support mechanism. BSH co-ordinates the preliminary environmental assessments and allocates offshore grid connections for projects before the project sites are competitively auctioned to developers. The preliminary environmental assessments completed by BSH are not sufficient to secure consent for the wind farm site. Developers are still required to undertake detailed environmental surveys, such as UXO surveys and micro-sitting of wind turbines. CfDs are awarded through competitive auctions held by **Bundesnetzagentur (the Federal Network Agency)**, which is the electricity regulator. The first auction is planned for 2021, with projects

1 P50 forecast, P50 ‘best guess’ means there is a 50% chance that forecast will be exceeded.

commissioned from 2026 onwards. Successful projects will get a 20-year power purchase agreement.

A transitional mechanism provides support to projects anticipated to be commissioned between 2021 and 2025. This allows developers of projects in advanced stages of development to bid for subsidy support before WindSeeG’s competitive auctioning concept is fully implemented.

Offshore grid connections are constructed, owned and operated by transmission system operators (TSOs) **TenneT** (North Sea) and **50Hz** (Baltic). Before the WindSeeG, the TSOs submitted an annual Offshore Grid Development Plan to the Federal Network Agency, setting out the plan for transmission assets. Under WindSeeG, this process is incorporated into the Area Development Plan.

## Organisations

**ForWind** is the joint Centre for Wind Energy Research of the Universities of Oldenburg, Hannover and Bremen.

**Fraunhofer IWES** is a technical analysis and testing facility with capability to test nacelles, drivetrain components, materials and support structures.

## Owners

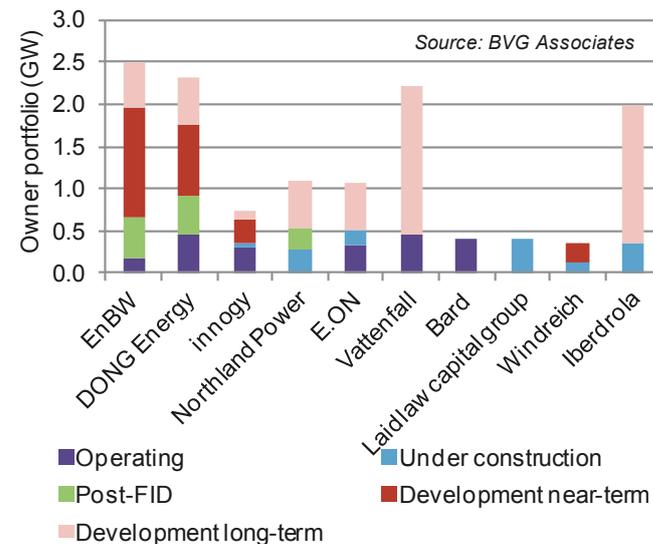


Figure 2 Top 10 owner portfolios.<sup>2</sup>

**DONG Energy** is an energy utility headquartered in Denmark. It has 100% ownership of Borkum Riffgrund 1 and 2 and Gode Wind 1 and 2 and approved consents for future deployment at Riffgrund West, Gode Wind 3 and OWP West.

**EnBW** is an energy utility headquartered in Germany. It owns the EnBW He Dreiht and EnBW Hohe See projects in development as well as consented Gode Wind 4 and OWP Albatross. It has shares in the operational Baltic 1 and 2

2 Owners are ranked based on their portfolio size from projects in operation to development near-term. Near term are projects currently in development anticipated to have year of first turbine installation before the end of 2025.



projects. Hohe See will be built with zero subsidy, making it the world's cheapest offshore wind farm.

**Vattenfall** is an energy utility headquartered in Sweden. It owns the operational Dan Tysk and Sandbank projects and the Global Tech 2 and Sandbank Extension projects. It also retains an interest in longer term development sites.

**E.ON** is an energy utility headquartered in Germany. It owns the operational Amrumbank West project, and the Arkona Becken Sudost project currently under construction and also has an interest in longer term potential projects.

**WindMW** is a specialist developer headquartered in Germany and owns the operating Meerwind Ost/Sud project.

**Innogy** is an energy utility headquartered in Germany. It operates the Nordsee Ost project, is developing the Kaskasi II project and has shares in Nordsee One, Two and Three.

**Iberdrola** is an energy utility headquartered in Spain. It is constructing the Wikinger project and is developing the Windanker project.

**Northland Power** is an independent power producer/specialist developer headquartered in Canada. It is developing the Deutsche Bucht site and has majority shares in the Nordsee One, Two and Three projects where is partnering with Innogy.

**Laidlaw** is an investment bank headquartered in the UK. It wholly owns the Veja Mate project currently under construction.

**Windreich** is a specialist developer headquartered in Germany. It is developing the Merkur Offshore and Ostseeschatz projects.

## Suppliers<sup>3</sup>

### Turbine supply

**Senvion** (formerly REpower) is a supplier of offshore wind turbines. In Germany Senvion will supply 443MW of turbine capacity to the Nordergründe and Nordsee One wind farms.

### Foundation supply

**Ambau** is a manufacturer of steel tubular structures. Its primary activity in the offshore wind industry is the production of turbine towers but it also has production capacity for monopile foundations and transition pieces. Ambau has recently supplied monopile foundations and transition pieces to Nordergründe and Nordsee One offshore wind farms.

**Steelwind Nordenham** is a manufacturer of steel tubular structures. Its primary activity in the offshore wind industry is the production of monopile foundations. Steelwind will supply Borkum Riffgrund 2 with 36 monopile foundations.

### Array and export cable supply

**NKT Cables** is a supplier of power cables with a production facility in Cologne. It has supplied array cables to Amrumbank and Baltic 1 wind farms as well as export cables to Baltic 1 and Borkum Riffgat.

### Offshore substation topside supply

**Cofely Fabricom (Fabricom)** is a construction contractor headquartered in Brussels. Its primary activity in the offshore wind industry is the assembly of offshore HVAC substation topsides and will supply topsides to the Gode Wind 1 and 2, Merkur and Veja Mate wind farms.

### Offshore substation electrical supply

**Siemens Energy Transmission** is the power transmission division of Siemens AG. Its primary activity in the offshore wind industry is the design of electrical interconnection systems and the supply of substation electrical equipment. They will supply the substation electrical equipment at Borkum Riffgrund 2.

### Turbine and foundation installation

**Fred Olsen Windcarrier** is a Norwegian vessel operator and installation contractor working exclusively within the offshore wind sector. Fred Olsen Windcarrier will supply turbine installation at Borkum Riffgrund 2, Veja Mate and Wikinger wind farms.

**GeoSea** is a Belgian marine construction company. Its primary activity in the offshore wind industry is the installation of foundations and turbines. It will install turbines at the Merkur offshore wind farm and foundations at Borkum Riffgrund 2, EnBW Hohe See, Gode Wind 1 and 2, and Nordsee One.

### Array and export cable installation

**Siem Offshore Contractors (SOC)** is subsea contractor. Its primary activity in the offshore wind industry is the installation of array and export cables. They will supply array cable installation at Borkum West II Phase 2, Nordsee One and Veja Mate as well as export cable installation at Nordsee One.

<sup>3</sup> Suppliers are a selection of those who have headquarters in the country or have been contracted on projects with year of first turbine installation in 2017 or after.

# Denmark

## Market growth

At the end of 2016, Denmark had 1.3GW of installed capacity. This is anticipated to reach 3.0GW by 2025.

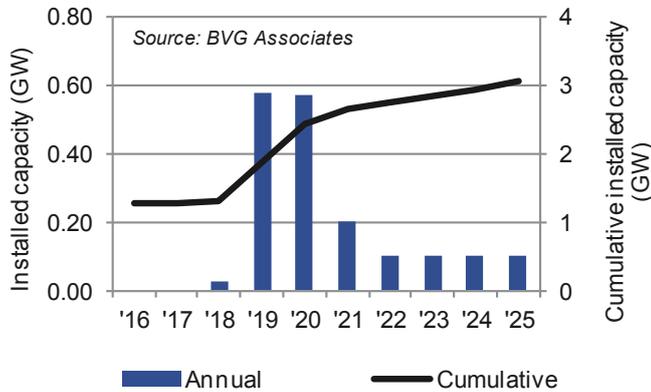


Figure 1 Forecast installed capacity.<sup>1</sup>

## Regulation

Leasing for offshore wind sites is managed by **The Danish Energy Agency (DEA)**. The Danish Energy Agency is used as a 'one-stop-shop' for all required licences and consenting activities. **Energinet.dk** is responsible for the electricity infrastructure in Denmark and acts as a transmission system operator (TSO). Offshore wind leases are normally given for 25 years and can be awarded through two procedures:

**Tender procedure:** The DEA announces a site-specific tender for a set project capacity (MW), having completed preliminary environmental investigations through a spatial planning committee and surveys managed by Energinet.dk. There were tenders in 1997, 2007, 2011 and 2012. Developers are invited to quote a fixed kWh price. The DEA negotiates with pre-qualified tenderers before awarding the site to the lowest bidder.

Energinet.dk designs, constructs and operates the offshore substation and the export cable.

In 2016, Vattenfall won the tender to build the 600MW Kriegers Flak project at a price of DKK 372/MWh (around €49.9/MWh) and the Danish Near Shore Wind tender for the Vesterhav Syd and Vesterhav Nord projects with a combined capacity of 350MW at a price of DKK 475/MWh (around €64/MWh). These are feed-in tariffs guaranteed for 50,000 full-load generating hours for a maximum of 20 years. After this period, the wind farm owner is paid the market price.

**Open-door procedure:** The developer identifies a potential offshore wind site and submits a licence application to undertake preliminary environmental investigations. The

<sup>1</sup> P50 forecast, P50 'best guess' means there is a 50% chance that forecast will be exceeded.

developer is not guaranteed a licence to construct and operate the wind farm.

In an open-door procedure, the developer pays for the grid connection to shore and the transmission of the electricity. The developer receives the same price for new onshore wind farms (DKK 250/MWh, around €37/MWh).

## Organisations

**Danish Wind Power Association** is an industry association with almost 250 members. It plays an important role in knowledge transfer in the supply chain and represents members' interest in national and international politics.

**LORC** is a non-profit and independent commercial foundation that offers test facilities to support innovation and demonstration of technology. It has a nacelle test facilities alongside mechanical and environmental test facilities for various components and structures.

**Technical University of Denmark (DTU)** is a university involved in the research of offshore wind technologies.

## Owners

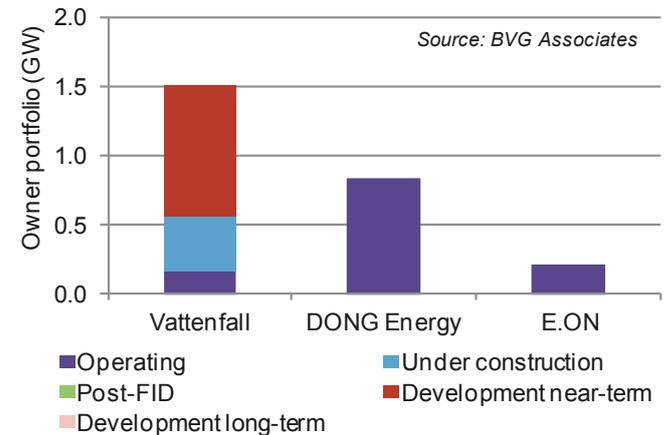


Figure 2 Top three owner portfolios.<sup>2</sup>

**Vattenfall** is an energy utility headquartered in Sweden. In Denmark, it secured the project rights to the Horns Rev 3, Vesterhav Nord and Vesterhav Syd offshore wind projects.

**DONG Energy** is an energy utility headquartered in Denmark. In Denmark, DONG Energy has almost 800MW of operational projects including Horns Rev 2 and Anholt.

**E.ON Climate and Renewables** is part of the German utility E.ON. In Denmark, E.ON operates the 207MW Rødsand II offshore wind farm.

<sup>2</sup> Owners are ranked based on their portfolio size from projects in operation to development near-term. Near term are projects currently in development anticipated to have year of first turbine installation before the end of 2025.



## Suppliers<sup>3</sup>

### Turbine supply

**MHI Vestas** is a supplier of offshore wind turbines and is a joint venture formed in April 2014 between Mitsubishi Heavy Industries (MHI) and Vestas. It will supply the Horns Rev 3 project.

**Siemens Wind Power** is a supplier of wind turbines. It has supplied almost 400 turbines to offshore projects in Denmark.

### Offshore substation topside supply

**Hollandia** is a fabricator of large offshore structures. Its primary activity in the offshore wind industry is the assembly of offshore substation jackets and topsides. It supplied the substation topside for the Kriegers Flak project.

**HSM Offshore** is a fabricator of large offshore structures. Its primary activity in the offshore wind industry is the design and assembly of HVAC offshore substation topsides and jackets. It supplied the offshore substation topsides for the Horns Rev 2 and Horns Rev 3 projects.

### Offshore substation electrical supply

**ABB** is a supplier of power and automation systems. Its primary activities in the offshore wind industry is the supply of substation electrical equipment. It supplied the Kriegers Flak and Horns Rev 3 projects.

### Turbine and foundation installation

**A2SEA** is a specialist offshore wind installation contractor and vessel owner. Its primary activity in offshore wind is the installation of turbines. The company is privately owned by DONG Energy and Siemens Wind Power. It has installed almost 450 offshore wind turbines in Denmark and will provide turbine installation for the Horns Rev 3 project.

**Swire Blue Ocean** is a vessel owner and operator headquartered in Denmark. Its primary activity in the offshore wind industry is the installation of turbines and foundations.

### Offshore substation installation

**Scaldis Salvage and Marine (Scaldis)** is a marine contractor and heavy lift specialist. Its primary activity in the offshore wind industry is the installation of foundations and offshore substations. It installed the offshore substations on the Kriegers Flak and Rødsand II projects.

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<sup>3</sup> Suppliers are a selection of those who have headquarters in the country or have been contracted on projects with year of first turbine installation in 2017 or after.

# France

## Market growth

At the end of 2016, France has no installed capacity. This is anticipated to reach 2.7GW by 2025.

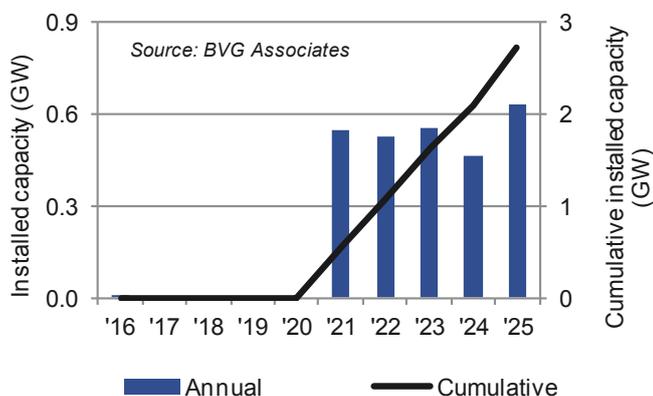


Figure 1 Forecast installed capacity.<sup>1</sup>

## Regulation

Projects were awarded in two rounds in 2012 and 2014 through a tender process based on price, project's technical value, industrial plan, environmental performance and existing activities.

In 2016, a new competitive tendering procedure was introduced. Applicants are pre-selected based on their technical and financial capabilities. The Energy ministry, the **Direction générale de l'énergie et du climat (DGEC)**, shortlists bidders and notifies **Commission de régulation de l'énergie (CRE)**, the independent body in charge of advising and reviewing the tender submissions.

The DGEC consults with the shortlisted applicant, the CRE, **Réseau de transport d'électricité** (RTE (the French transmission operator)) and other stakeholders in order to define the wind farm site and tailor the specifications of the tender.

The applicants are then invited to submit to CRE their final offer. The assessment criteria have not been finalised but are likely to be extended to include energy efficiency, technology innovation, project profitability and investment strategy. The applicants are selected by the DGEC and a feed-in tariff price granted for 20 years. RTE builds and operates the transmission for offshore wind projects.

The developer is not guaranteed an offshore wind lease, even if they win the tendering procedure. The leasing for offshore wind is granted by the local préfet after consultations with the local authorities and a public debate procedure monitored by the **Commission nationale du débat public (CNDP)**. Offshore wind leases are given for a maximum of 30 years.

<sup>1</sup> P50 forecast, P50 'best guess' means there is a 50% chance that forecast will be exceeded.

## Organisations

**Agence de l'Environnement et de la Maîtrise de l'Énergie (ADEME)** is the national energy agency and runs funds for innovation and new technology and has a consulting role to the DGEC.

**France Énergie Eolienne (FEE)** is France's not-for profit wind energy trade association. It supports industry through collaborative working groups and policy forums.

**France Energies Marines** is a public-private research Institute dedicated to marine renewable energies. It supports the offshore wind and wave and tidal sector by providing technical support and funding R&D.

**Pôle Mer Bretagne Atlantique** is a regional economic development that stimulates the Brittany and Atlantic coast marine supply chain.

**Pôle Mer Méditerranée** is a regional economic development that stimulates the Mediterranean coast marine supply chain.

**Syndicat des énergies renouvelables (SER)** is the French renewables sector organisation which promotes the interests of French industry and professionals in renewable energy, coordinating industry activity and lobbying the government.

## Owners

**EDF Energies Nouvelles** is an energy utility headquartered in France. It has a share in the Calvados (Courseulles sur Mer), Faraman, Fécamp and Saint-Nazaire projects.

**Enbridge** is an energy utility headquartered in Canada. It has a share in the Calvados (Courseulles sur Mer), Fécamp and Saint-Nazaire.

**Iberdola** is an energy utility headquartered in Spain. It has a share in the Saint-Brieuc project.

**Engie** is an energy utility headquartered in France. It has a share in the Leucate, Le Tréport and Noirmoutier projects.

**WPD** is a specialist developer headquartered in Germany. It has a share in the Calvados (Courseulles sur Mer) and Fécamp projects.

**EDP Renováveis** is headquartered in Spain. It has a share in the Leucate, Le Tréport and Noirmoutier projects.

**Eole Res** is a specialist developer headquartered in France. It is a subsidiary of the RES Group. It has a share in the Saint-Brieuc project.

**NEOEN** is an independent power producer headquartered in France. It has a share in the Le Tréport project.

**Caisse de depot et placement du Quebec** is an institutional investor headquartered in Canada. It has a share in the Saint-Brieuc project.

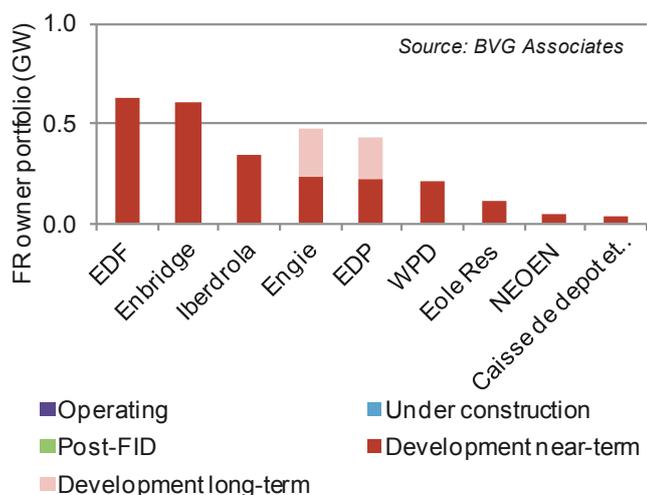


Figure 2 Top nine owner portfolios.<sup>2</sup>

In France, some developers have formalised collaborations:

- EDF and Enbridge to form Eolien Maritime France
- Eole RES and Caisse des depots to form Avel Vor

## Suppliers<sup>3</sup>

### Turbine supply

**Adwen** is a supplier of offshore wind turbines. The company's focus is currently on the French market where it has secured a pipeline of 1,500MW in partnership with Iberdrola. The performance of its new 8MW prototype and type certification timeline is likely to determine the company's success outside this core market. Adwen was originally a 50/50 joint venture between Areva and Gamesa. In June 2016, Siemens and Gamesa merged and in September 2016, together acquired Areva's 50% share in Adwen.

**GE/Alstom** is a supplier of offshore wind turbines. In 2015, GE acquired the power and grid divisions of Alstom. While Alstom's onshore wind business (formerly Ecotechnia) was absorbed into GE Wind, the two companies established a joint venture for the offshore wind business. The company is managed by GE. In 2016, GE acquired blade manufacturer LM Wind Power. GE/Alstom has secured a significant pipeline of 1.5GW of French capacity in partnership with the developers EDF Energies Nouvelles, DONG Energy and WPD offshore.

<sup>2</sup> Owners are ranked based on their portfolio size from projects in operation to development near-term. Near term are projects currently in development anticipated to have year of first turbine installation before the end of 2025.

<sup>3</sup> Suppliers are a selection of those who have headquarters in the country or have been contracted on projects with year of first turbine installation in 2017 or after.

### Offshore substation topside supply

**STX France Solutions** is a French shipbuilder and fabricator of large offshore structures. It is primarily involved in the design and assembly of HVAC offshore substation topsides and jackets. It is also seeking to enter the turbine foundation market.

### Offshore substation electrical supply

**GE Grid Solutions** is a supplier and systems engineer for transmission and distribution networks. Its primary activity in the offshore wind industry is the design of electrical interconnection systems and the supply of substation electrical equipment. GE acquired the business from Alstom in 2015.

# The Netherlands

## Market growth

At the end of 2016, the Netherlands had 1.1GW of installed capacity. This is anticipated to reach 4.7GW by 2025.

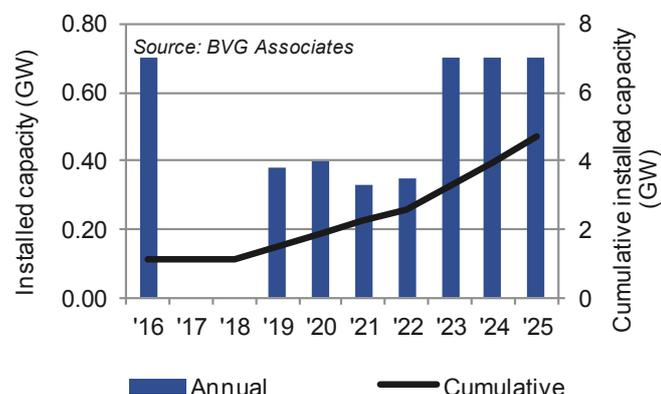


Figure 1 Forecast installed capacity.<sup>1</sup>

## Regulation

The **Ministerie van Economische Zaken (Ministry of Economic Affairs)** is the government department that promotes the development of clean, reliable energy and, through the National Water Plans (NWP), determines where offshore wind projects should be located. In the Netherlands, offshore wind projects are awarded to developers through competitive tenders. The Government completes preliminary environmental investigations, which allows developers to tender for the project at the lowest cost. Preliminary environmental data is published by the **Netherlands Enterprise Agency (RVO.nl)**. For tenders between 2015-2019, the Government reserved a maximum of €18billion for renewable energy subsidies. A maximum price is also set for each wind farm site. The tender is awarded to the lowest price bidder, which must be equal to or lower than the maximum price. The winning developer secures a contract for difference (CfD) subsidy for 15 years, consent to build the wind farm and a 30-year operating licence from ROV.nl. In 2014, the Ministry Of Economic Affairs appointed TenneT as the transmission system operator (TSO). It has developed plans to link all the new Netherlands projects through an offshore link, potentially connecting to German North Sea projects also.

<sup>1</sup> P50 forecast, P50 'best guess' means there is a 50% chance that forecast will be exceeded.

| Project                 | Capacity | Tender winner                             | Price <sup>2</sup> |
|-------------------------|----------|---|--------------------|
| <b>BORSSELE 1 AND 2</b> | 700MW    | DONG Energy                               | €72.70 / MWh       |
| <b>BORSSELE 3 AND 4</b> | 680MW    | Shell, Van Oord, Eneco and Mitsubishi/DGE | €54.50 / MWh       |
| <b>BORSSELE 5</b>       | 20MW     | Not yet tendered                          | -                  |
| <b>SOUTH HOLLAND</b>    | 1,400MW  | Not yet tendered                          | -                  |
| <b>NORTH HOLLAND</b>    | 700MW    | Not yet tendered                          | -                  |

Table 1 Netherlands project and tender information.

## Organisations

**Delft University of Technology (TU Delft)** is a university involved in the research of offshore wind technologies.

**Energy Research Centre of the Netherlands (ECN)** is an energy research institute with a research programme focused on wind energy. Its primary focus is to reduce the cost of energy through technology innovation and make the Netherlands industry more competitive as a result.

## Owners

**DONG Energy** is an energy utility headquartered in Denmark. In the Netherlands, DONG Energy owns the Borssele 1 and Borssele 2 projects.

**Eneco** is an independent energy company owned by 55 Dutch municipalities and headquartered in the Netherlands. It owns the operational Prinses Amaliawindpark and Eneco Luchterduinen projects.

**Northland Power** is an independent power producer and specialist developer headquartered in Canada. It typically invests in projects once consent is approved. It has shares in the Gemini project.

**Van Oord Offshore Wind Projects** is part of the Van Oord dredging and marine contracting business headquartered in the Netherlands. It has shares in the Gemini and Borssele three and four projects.

**Royal Dutch Shell** is a multi-national company headquartered in the Netherlands. Its primary business is oil and gas but has shares in Borssele three and four and is making a growing commitment to offshore wind.

**Mitsubishi DGE** is a subsidiary of Mitsubishi Corporation, which has European headquarters in the UK. It has shares in the Borssele three and four projects.

<sup>2</sup> Price excludes transmission.



**Westermeer Wind** owns the Westermeer Wind project.

**Siemens Wind Power** is turbine supplier to the Gemini wind farm, in which it holds shares.

**Vattenfall** is a utility headquartered in Sweden. It owns the operating Irene Vorrink project and has shares in the operating Egmond aan Zee project. In 2016, it decommissioned the 2MW Lely project.

**HVC** is owned by 52 participating municipalities in North Holland, Flevoland, South Holland and Friesland and five water districts. It has shares in the Gemini project.

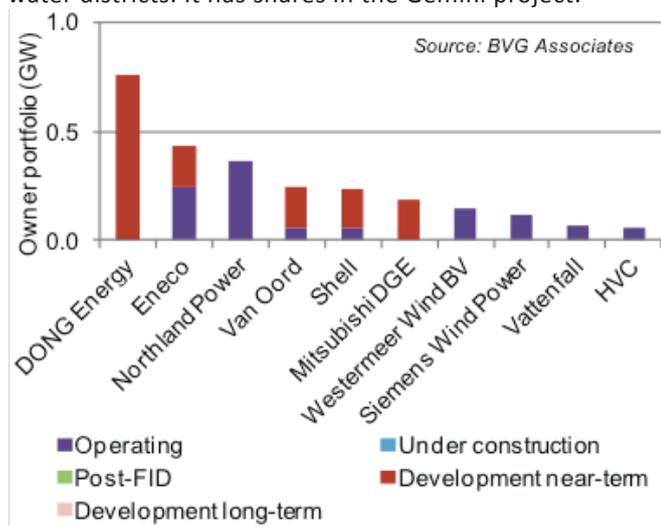


Figure 2 Top 10 owner portfolios.<sup>3</sup>

## Suppliers<sup>4</sup>

### Foundation supply

**Bladt Industries** is a Danish manufacturer of offshore steel structures. Its primary activities in the offshore wind industry is the manufacture of steel foundations and assembly of substation jackets and topsides. It supplied transition pieces for the Egmond aan Zee and Gemini projects.

**Sif Group** is a Dutch manufacturer of steel tubular structures. It produces of monopile foundations and pin piles for jacket foundations. It supplied foundations to the operating Gemini, Prinses Amaliawindpark, Eneco Luchterduinen and Westermeerwind projects.

<sup>3</sup> Owners are ranked based on their portfolio size from projects in operation to development near-term. Near term are projects currently in development anticipated to have year of first turbine installation before the end of 2025.

<sup>4</sup> Suppliers are a selection of those who have headquarters in the country or have been contracted on projects with year of first turbine installation in 2017 or after.

### Array and export cable supply

**Norddeutsche Seekabelwerke (NSW (General Cable))** is a supplier of power and communication cables. Its primary activities in the offshore wind industry are the supply and installation of array and export cables. It supplied array cables for the Gemini project.

### Offshore substation topside supply

**Heerema Fabrication Group (Heerema)** is a construction contractor headquartered in the Netherlands. Its primary activity in the offshore wind industry is the assembly of offshore HVAC and HVDC substations.

### Offshore substation electrical supply

**CG Power Solutions** is a supplier and systems engineer for transmission and distribution networks. Its primary activity in the offshore wind industry is the design of electrical interconnection systems and the supply of substation electrical equipment. It supplied the substation electrical equipment for the Gemini offshore substations.

### Turbine and foundation installation

**Royal Boskalis Westminster** is an offshore contractor. Its primary activity in the offshore wind industry is the installation of foundations and substations. Boskalis is a listed Dutch company.

**Van Oord** is a installer of turbines, foundations and export and array cables. It provided turbine and foundation installation for the Gemini (in which it has an equity stake), Eneco Luchterduinen and Westermeerwind projects.

### Array and export cable installation

**Fugro** is a marine geotechnical and geosciences service provider headquartered in the Netherlands. Its primary activity in the offshore wind industry is geotechnical and geophysical services but it also installs array cables.

**Tideway** is a subsea contractor, part of the DEME group, headquartered in the Netherlands. Its primary activity in the offshore wind industry is the installation of scour protection but it has also installed array and export cables.

# UK

## Market growth

At the end of 2016, the UK had 5.3GW of installed capacity. This is anticipated to reach 17.0GW by 2025.

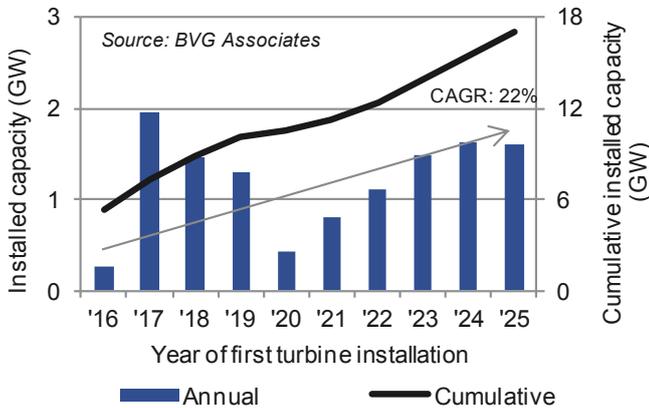


Figure 1 Forecast installed capacity with compound annual growth rate (CAGR).<sup>1</sup>

## Regulation

Leasing for offshore wind sites is managed by **The Crown Estate** through several leasing rounds that began in 2000, the latest of which was in 2010. The Scottish and UK Governments are currently working to devolve the management of The Crown Estate assets in Scotland. A phased approach will be managed by an interim body from April 2017.

Offshore wind projects in England and Wales are defined as nationally significant infrastructure projects and are examined by the **Planning Inspectorate**. The Secretary of State for the **Department for Business, Energy and Industrial Strategy** grants or refuses consent based on a recommendation made by the Planning Inspectorate. In Scotland, **Marine Scotland** examines applications and Scottish Ministers grant or refuse consent.

The support mechanism for projects that have not reached final investment decision is through Contracts for Difference (CfDs). CfDs last 15 years. CfDs are awarded through allocation rounds. The first allocation round was completed in February 2015 with two offshore wind projects awarded a CfD, East Anglia One and Neart na Gaoithe, at strike prices of £120 and £114 respectively<sup>2</sup>. A second CfD allocation round will take place in 2017 for projects to be delivered in years 2021/22 and 2022/23.

Renewable Obligation Certificates (ROCs) have been in

1 P50 forecast, P50 'best guess' means there is a 50% chance that forecast will be exceeded.

2 The Neart na Gaoithe project's CfD was cancelled by the Low Carbon Contracts Company on 29 March 2016. The project developer failed to reach a final investment decision by the deadline of 26 March 2017. The developer is involved in an ongoing judicial review with RSPB over potential impacts with birds.

operation since 2002 and will end for new projects at the end of March 2017. Final Investment Decision Enabling for Renewables (FIDeR) has been the transitional support mechanism set-up as a way to maintain a stable level of market growth between the ROC and the CfD regimes.

Offshore Transmission Owners (OFTOs) are granted licences to own and operate offshore transmission assets through competitive tender processes. Developers typically take up an option to build the transmission assets and sell on within 18 months of wind farm commissioning.

## Organisations

**Offshore Renewable Energy (ORE) Catapult** is a research institute with capacity for turbine blade and drivetrain test facilities.

**RenewableUK** is the UK's not for profit renewable energy trade association. It organises industry conferences and supports industry through collaborative working groups and policy forums.

**The Carbon Trust** has a mission to 'reduce carbon emissions and develop commercial low carbon technologies', such as through the Offshore Wind Accelerator.

## Owners

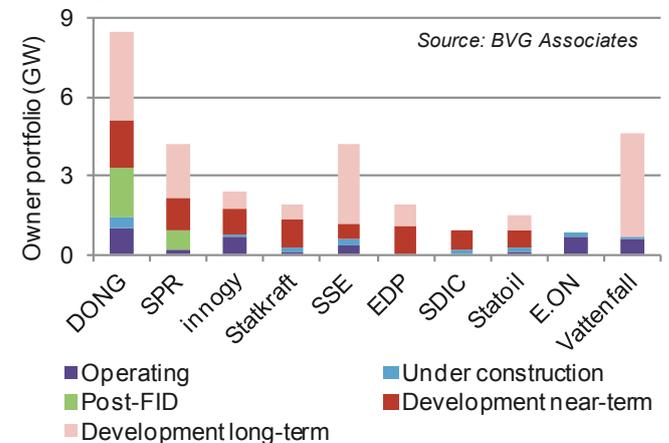


Figure 2 Top 10 owner portfolios.<sup>3,4</sup>

**DONG Energy** is an energy utility headquartered in Denmark. In the UK market DONG Energy has ownership in Race Bank and the Burbo Bank Extension both currently under construction.

**ScottishPower Renewables (SPR)** is a UK utility and part of the Spanish energy utility Iberdrola. The company owns the post-FID East Anglia One project in the UK as well as three further East Anglia projects.

3 Statkraft and SSE have announced their intention to exit the market.

4 Owners are ranked based on their portfolio size from projects in operation to development near-term. Near term are projects currently in development anticipated to have year of first turbine installation before the end of 2025.



**Innogy UK** is a UK utility and a subsidiary of the German energy company RWE responsible for its UK renewable business. In the UK Innogy has joint-ownership of the Galloper project as well as the Dogger Bank and Triton Knoll wind farms in development.

**Statkraft** is a utility headquartered in Norway. It recently announced an exit from offshore wind and has signed memorandum of understanding for its shares to be acquired by Statoil.

**SSE** is a utility headquartered in the UK. It has announced it will streamline its involvement in offshore wind and may not build the projects it owns in development.

**EDP Renováveis** is headquartered in Spain. It owns the Moray Firth Western and Eastern projects.

**SDIC Power** is a sovereign wealth fund with headquarters in China. It is 100% owner of the Inch Cape project.

**Statoil** is headquartered in Norway. Its Dudgeon project is currently under construction and it has shares in Dogger Bank Creyke Beck and Dogger Bank Teesside.

**E.ON Climate and Renewables** is a UK utility with a German parent. In the UK it owns the operational projects Humber Gateway, a share of London Array, Robin Rigg and Scroby Sands. The Rampion project is currently under construction.

**Vattenfall** is a utility headquartered in Sweden. It has a large development pipeline, owning 100% of the East Anglia Norfolk Boreas and Vanguard projects.

## Suppliers<sup>5</sup>

### Turbine supply

**Siemens Wind Power** is a turbine supplier. It has supplied over 1,000 offshore wind turbines to offshore wind projects in the UK.

### Foundation supply

**Burntisland Fabrications (BiFab)** is a fabricator of large offshore structures. Its primary offshore wind activity is the production of turbine jacket foundations.

**Smulders Projects** is a Belgian fabricator of large offshore structures. It will supply transition pieces for Dudgeon, Galloper and Rampion as well as jacket foundations for the Beatrice offshore wind farm. It frequently partners with the specialist steel rolling company Sif.

### Array and export cable supply

**JDR Cable Systems** is a supplier of array cables with a deepwater access production facility and an estimated annual cable capacity of 300km.

### Offshore substation topside supply

**Babcock** is a supplier of topside structures with capability to build structures with masses of up to 15,000t. It has recently entered the market by securing the Rampion substation contract.

**Harland & Wolff** is a fabricator of large offshore structures. Its primary activity in the offshore wind industry is the assembly of HVAC offshore substation topsides and jackets. It has also entered the turbine foundation market.

**Sembmarine SLP** is a fabricator of large offshore structures. Its primary activity in the offshore wind industry is the assembly of HVAC substations.

### Turbine and foundation installation

**MPI Offshore** is a marine contractor, active as an installer of turbines and foundations. MPI Offshore pioneered the development of specialist offshore turbine installation vessels and now operates a fleet of four vessels.

**Seajacks** is an owner and operator of jack-up construction vessels for installation of turbines and foundations. Seajacks operates a fleet of five installation vessels.

### Array and export cable installation

**DeepOcean** is a subsea contractor. Its primary activity in offshore wind is the installation of array and export cables, as well as cable survey, inspection and repair.

**VBMS** is a Dutch vessel owner and operator wholly owned by Boskalis. VBMS were awarded array cable installation contracts at the Dudgeon, Galloper, Walney Extension and East Anglia One projects.

### Offshore substation installation

**Seaway Heavy Lifting** is a Dutch offshore contractor and vessel owner. Seaway have been selected for substation installation at Dudgeon and the extensions at Walney and Burbo Bank.

<sup>5</sup> Suppliers are a selection of those who have headquarters in the country or have been contracted on projects with year of first turbine installation in 2017 or after.

# Appendix B: Supply chain assessment

Summary of the sub-element opportunity scores for the Norwegian supply chain.

| Element                                   | Sub-element                         | Track record in offshore wind | Synergies between offshore wind and other Norwegian sectors | Appetite from offshore wind | Potential for LCOE benefit from new involvement by Norwegian companies | Size and timing of investments by Norwegian companies | Size of the opportunity | Opportunity for Norwegian companies |
|---|-------------------------------------|-------------------------------|---|-----------------------------|--|---|-------------------------|-------------------------------------|
| <b>DEVELOPMENT AND PROJECT MANAGEMENT</b> | Environmental surveys               | 1                             | 2   | 1                           | 1  | 4   | 1                       |                                     |
|   | Consenting and development services | 1                             | 2   | 1                           | 1  | 4   | 1                       |                                     |
|   | Site investigations                 | 2                             | 3   | 2                           | 1  | 3   | 1                       |                                     |
|   | Project management                  | 2                             | 4   | 3                           | 3  | 4   | 2                       |                                     |
| <b>TURBINE SUPPLY</b>                     | Turbine assembly                    | 1                             | 2   | 2                           | 1  | 3   | 2                       |                                     |
|   | Blades                              | 1                             | 1   | 1                           | 1  | 1   | 3                       |                                     |
|   | Drive train                         | 1                             | 2   | 1                           | 1  | 1   | 3                       |                                     |
|   | Power conversion                    | 1                             | 1   | 1                           | 1  | 1   | 3                       |                                     |
|   | Large fabrications                  | 1                             | 2   | 1                           | 1  | 2   | 2                       |                                     |
|   | Towers                              | 1                             | 2   | 1                           | 1  | 2   | 3                       |                                     |
|   | Small components                    | 1                             | 2   | 1                           | 1  | 2   | 2                       |                                     |
| <b>BALANCE OF PLANT</b>                   | Subsea cables                       | 4                             | 4   | 3                           | 3  | 3   | 3                       |                                     |
|   | Electrical systems                  | 1                             | 3   | 2                           | 2  | 3   | 3                       |                                     |
|   | Offshore substation structures      | 2                             | 4   | 2                           | 3  | 3   | 3                       |                                     |
|   | Turbine foundations                 | 2                             | 4   | 4                           | 4  | 3   | 4                       |                                     |
|   | Secondary steelwork                 | 2                             | 3   | 2                           | 2  | 4   | 2                       |                                     |



| Element                                   | Sub-element                                 | Track record in offshore wind | Synergies between offshore wind and other Norwegian sectors | Appetite from offshore wind | Potential for LCOE benefit from new involvement by Norwegian companies | Size and timing of investments by Norwegian companies | Size of the opportunity | Opportunity for Norwegian companies |
|---|---|-------------------------------|---|-----------------------------|--|---|-------------------------|-------------------------------------|
| <b>INSTALLATION AND COMMISSIONING</b>     | Installation ports and logistics            | 2                             | 3   | 2                           | 1  | 3   | 1                       |                                     |
|   | Turbine and foundation installation         | 2                             | 3   | 3                           | 2  | 2   | 3                       |                                     |
|   | Cable installation                          | 2                             | 3   | 2                           | 1  | 3   | 1                       |                                     |
|   | Substation installation                     | 1                             | 4   | 3                           | 1  | 4   | 2                       |                                     |
|   | Installation equipment and support services | 2                             | 4   | 4                           | 4  | 4   | 2                       |                                     |
|   | Onshore works                               | 1                             | 1   | 1                           | 1  | 4   | 1                       |                                     |
| <b>OPERATION, MAINTENANCE AND SERVICE</b> | Maintenance and inspection services         | 2                             | 4   | 4                           | 4  | 4   | 4                       |                                     |
|   | Vessels and equipment                       | 2                             | 4   | 4                           | 4  | 4   | 3                       |                                     |
|   | O&M ports                                   | 1                             | 4   | 2                           | 1  | 3   | 1                       |                                     |
| <b>DECOMMISSIONING</b>                    | Ports and logistics                         | 1                             | 4   | 2                           | 1  | 4   | 1                       |                                     |
|   | Marine operations                           | 1                             | 4   | 3                           | 1  | 4   | 1                       |                                     |
|   | Salvage and recycling                       | 1                             | 4   | 4                           | 1  | 4   | 1                       |                                     |
|   | Project management                          | 1                             | 4   | 3                           | 1  | 4   | 1                       |                                     |

# Appendix C: Supplier capabilities

|              |                                 | Value chain  |  |  |
|--------------|---------------------------------|--|--|--|
|              |                                 | Development  | Construction   | Operation, maintenance and service   |
| Supply chain | <b>SERVICE PROVIDERS</b>        | <ul style="list-style-type: none"> <li>• Consulting</li> <li>• Engineering</li> <li>• Environmental surveys</li> <li>• Financial services</li> <li>• Industry enabling</li> <li>• Instrumentation</li> <li>• Legal services</li> <li>• Metocean data</li> <li>• Project management</li> <li>• R&amp;D</li> <li>• Site investigation</li> <li>• Software</li> <li>• Support services</li> <li>• Training</li> </ul> | <ul style="list-style-type: none"> <li>• Access systems</li> <li>• Ancillary items</li> <li>• Asset management</li> <li>• Communications</li> <li>• Component handling</li> <li>• Consulting</li> <li>• Support services</li> <li>• Engineering</li> <li>• Environmental survey</li> <li>• Foundations</li> <li>• Instrumentation</li> <li>• Metocean data</li> <li>• Project management</li> <li>• Ship brokers</li> <li>• Ship owners</li> <li>• Subsea engineering</li> <li>• Support services</li> <li>• Vessel manufacture</li> <li>• Vessel operators</li> <li>• Warehousing and inventory management</li> </ul> | <ul style="list-style-type: none"> <li>• Ancillary items</li> <li>• Asset management</li> <li>• Cables</li> <li>• Communications</li> <li>• Consulting</li> <li>• Engineering</li> <li>• Environmental surveys</li> <li>• Health and safety</li> <li>• Instrumentation</li> <li>• Metocean data</li> <li>• Project management</li> <li>• Ship brokers</li> <li>• Ship owners</li> <li>• Software</li> <li>• Subsea engineering</li> <li>• Support services</li> <li>• Vessel manufacture</li> <li>• Vessel operators</li> <li>• Weather forecasting</li> </ul> |
|              | <b>MAIN COMPONENT SUPPLIERS</b> |  | <ul style="list-style-type: none"> <li>• Cables</li> <li>• Foundations</li> <li>• Substations</li> <li>• Turbines</li> </ul>   | <ul style="list-style-type: none"> <li>• Access systems</li> </ul>   |
|              | <b>MAIN CONTRACTORS</b>         |  | <ul style="list-style-type: none"> <li>• Electrical contractors</li> <li>• EPCI and marine contractors</li> <li>• Marine contractors</li> </ul>  | <ul style="list-style-type: none"> <li>• Marine contractors</li> </ul>   |
|              | <b>EQUIPMENT SUPPLIERS</b>      | <ul style="list-style-type: none"> <li>• Instrumentation</li> <li>• R&amp;D</li> </ul>   | <ul style="list-style-type: none"> <li>• Ancillary items</li> <li>• Cranes</li> <li>• Health and safety</li> <li>• Instrumentation</li> <li>• R&amp;D</li> <li>• Turbines</li> </ul>   | <ul style="list-style-type: none"> <li>• Ancillary items</li> <li>• Cranes</li> <li>• Health and safety</li> <li>• Instrumentation</li> <li>• Turbines</li> </ul>  |



| SUPPLY AREA                   | SUPPLIER  |   |
|-------------------------------|---|---|
| <b>ACCESS SYSTEMS</b>         | <ul style="list-style-type: none"> <li>Alustar AS</li> <li>Kongsberg Maritime AS</li> <li>MacGregor AS</li> </ul>   | <ul style="list-style-type: none"> <li>Ulla Maritime AS</li> <li>Uptime International AS</li> </ul>   |
| <b>ANCILLARY ITEMS</b>        | <ul style="list-style-type: none"> <li>AF Offshore AeronMollier AS</li> <li>Baggerød AS</li> <li>Brothers AS</li> <li>Dokka Fasteners AS</li> <li>Framo AS</li> <li>Glamox AS</li> <li>Helifuel AS</li> <li>Highcomp AS</li> <li>Hitec Products AS</li> </ul> | <ul style="list-style-type: none"> <li>Imenco AS</li> <li>John Dahle Skipshandel AS</li> <li>Jotun AS</li> <li>Noratel AS</li> <li>Øglænd System AS</li> <li>Partner Plast AS</li> <li>Rapp - Bomek AS</li> <li>Trans Construction AS</li> <li>Trelleborg Offshore Norway AS</li> </ul> |
| <b>ASSET MANAGEMENT</b>       | <ul style="list-style-type: none"> <li>Karsten Moholt AS</li> <li>Linjebygg Offshore AS</li> </ul>  | <ul style="list-style-type: none"> <li>NSG Wind AS</li> <li>Solid vedlikehold</li> </ul>  |
| <b>CABLES</b>                 | <ul style="list-style-type: none"> <li>Prysmian (Draka Norsk Kabel) AS</li> <li>Nexans AS</li> <li>Seaproof Solutions AS</li> </ul>   | <ul style="list-style-type: none"> <li>Transmark Subsea AS</li> <li>Wirescan AS</li> </ul>  |
| <b>COMMUNICATIONS</b>         | <ul style="list-style-type: none"> <li>Baze Technology AS</li> <li>Ceragon Networks AS</li> <li>Eaton (HERNIS) AS</li> <li>General Industry Systems AS</li> </ul>   | <ul style="list-style-type: none"> <li>Jotron AS</li> <li>Norphonic AS</li> <li>Telenor Maritime AS</li> <li>TSAT</li> </ul>  |
| <b>COMPONENT HANDLING</b>     | <ul style="list-style-type: none"> <li>TTS Handling Systems As</li> </ul>   |   |
| <b>CONSULTING</b>             | <ul style="list-style-type: none"> <li>Aqualis Offshore AS</li> <li>DNV GL AS</li> <li>Force Technology Norway AS</li> <li>Lloyd's Register</li> <li>MainTech AS</li> </ul>   | <ul style="list-style-type: none"> <li>Rystad Energy AS</li> <li>Semar AS</li> <li>Sund Energy AS, Oslo</li> <li>Sweco AS</li> <li>Thema Consulting Group AS</li> </ul>   |
| <b>CRANES</b>                 | <ul style="list-style-type: none"> <li>ACE Winches Norge AS</li> <li>Cranemaster AS</li> <li>I.P. Huse AS</li> </ul>  | <ul style="list-style-type: none"> <li>MacGregor Norway AS</li> <li>OptiLift</li> <li>Palfinger Dreggen AS</li> </ul>   |
| <b>ELECTRICAL CONTRACTORS</b> | <ul style="list-style-type: none"> <li>ABB AS</li> </ul>  | <ul style="list-style-type: none"> <li>Scanelec AS</li> </ul>   |
| <b>ENGINEERING</b>            | <ul style="list-style-type: none"> <li>Fedem Technology AS</li> <li>Femkuber AS</li> <li>Future Technology AS</li> <li>Head Energy AS</li> <li>IKM Group AS</li> <li>IOS InterMoor AS</li> <li>Kongstein AS</li> </ul>  | <ul style="list-style-type: none"> <li>Light Structures AS</li> <li>Moss Maritime AS</li> <li>Multiconsult ASA</li> <li>Norconsult AS</li> <li>Offshore Kinetics AS</li> <li>Prezioso - Linjebygg AS</li> <li>Scan Tech AS</li> </ul>   |
| <b>ENVIRONMENTAL</b>          | <ul style="list-style-type: none"> <li>SeaCult AS</li> </ul>  |   |
| <b>ENVIRONMENTAL SURVEYS</b>  | <ul style="list-style-type: none"> <li>ISurvey AS</li> </ul>  | <ul style="list-style-type: none"> <li>Parker Maritime AS</li> </ul>  |

| SUPPLY AREA                        | SUPPLIER   |   |
|------------------------------------|--|---|
| <b>EPCI AND MARINE CONTRACTORS</b> | <ul style="list-style-type: none"> <li>Aker Solutions ASA</li> <li>FMC Norge AS</li> <li>Fred. Olsen Windcarrier AS</li> </ul>   | <ul style="list-style-type: none"> <li>Subsea 7, Norway</li> <li>Technip</li> </ul>   |
| <b>FINANCIAL SERVICES</b>          | <ul style="list-style-type: none"> <li>DNB ASA</li> <li>Export Credit Norway</li> </ul>  | <ul style="list-style-type: none"> <li>GIEK</li> </ul>  |
| <b>FOUNDATIONS</b>                 | <ul style="list-style-type: none"> <li>Aker Solutions ASA</li> <li>Aibel AS</li> <li>Amon</li> <li>Arild Bolsø Engineering</li> </ul>  | <ul style="list-style-type: none"> <li>Dr.techn.Olav Olsen AS</li> <li>Kvaerner AS</li> <li>Owec Tower</li> <li>Seatower AS</li> </ul>  |
| <b>HEALTH AND SAFETY</b>           | <ul style="list-style-type: none"> <li>Align AS</li> <li>Autronica Fire &amp; Security</li> <li>Consilium Oil&amp;Gas AS</li> <li>Dacon AS</li> </ul>                            | <ul style="list-style-type: none"> <li>Firenor AS</li> <li>Gexcon AS</li> <li>Hansen Protection AS</li> </ul>   |
| <b>INDUSTRY ENABLING</b>           | <ul style="list-style-type: none"> <li>GCE Blue Maritime Cluster</li> <li>GCE NODE</li> <li>GCE Subsea</li> <li>Greater Stavanger Economic Development</li> </ul>                | <ul style="list-style-type: none"> <li>Maritimt Forum for Haugalandet og Sunnhordland</li> <li>Maritimt Forum for Stavangerregionen</li> <li>NCE Maritime Cleantech</li> <li>Norwegian Energy Partners</li> </ul> |
| <b>INSTRUMENTATION</b>             | <ul style="list-style-type: none"> <li>Aanderaa Data Instruments AS</li> <li>Clampon</li> <li>Emip AS</li> <li>Goodtech ASA</li> </ul>   | <ul style="list-style-type: none"> <li>Kongsberg Digital</li> <li>Mera AS</li> <li>Nortek AS</li> </ul>   |
| <b>LEGAL SERVICES</b>              | <ul style="list-style-type: none"> <li>Advokatfirmaet Steenstrup Stordrange DA</li> <li>DLA Piper AS</li> <li>Kvale Advokatfirma DA</li> </ul>                                   | <ul style="list-style-type: none"> <li>Kyllingstad Kleveland Advokatfirma DA</li> <li>Selmer ASA</li> <li>Wikborg Rein Advokatfirma</li> </ul>  |
| <b>MARINE CONTRACTORS</b>          | <ul style="list-style-type: none"> <li>DeepOcean AS</li> <li>Eide Marine Services AS</li> </ul>  | <ul style="list-style-type: none"> <li>GMC Maritime</li> <li>Siem Offshore Contractors</li> </ul>   |
| <b>METOCEAN DATA</b>               | <ul style="list-style-type: none"> <li>Automasjon &amp; Data AS</li> <li>Fugro Oceanor AS</li> <li>Gexcon AS</li> <li>Kjeller Vindteknikk</li> <li>Meventus AS</li> </ul>        | <ul style="list-style-type: none"> <li>Miros AS</li> <li>Storm Geo AS</li> <li>WindMaster Technologies AS</li> <li>WindSim AS</li> </ul>  |
| <b>PROJECT MANAGEMENT</b>          | <ul style="list-style-type: none"> <li>Aqualis ASA</li> <li>EA Group AS</li> <li>Havgul Frontier AS, Oslo</li> </ul>   | <ul style="list-style-type: none"> <li>Inocean AS</li> <li>Statoil ASA, New Energy</li> </ul>   |
| <b>R&amp;D</b>                     | <ul style="list-style-type: none"> <li>Christian Michelsen Research</li> <li>Easy Form AS</li> <li>Høyskolen I Ålesund</li> <li>Institute for Energy Technology (IFE)</li> </ul> | <ul style="list-style-type: none"> <li>NTNU</li> <li>Stiftelsen Polytec</li> <li>Universitetet i Oslo (UiO)</li> </ul>  |



| SUPPLY AREA                      | SUPPLIER   |  |
|----------------------------------|--|--|
| <b>SHIP BROKERS</b>              | <ul style="list-style-type: none"> <li>• Clarksons Platou Ltd</li> <li>• MarLog AS</li> </ul>  | <ul style="list-style-type: none"> <li>• Seabrokers Chartering</li> <li>• TP Shipping</li> </ul>   |
| <b>SHIP OWNERS AND OPERATORS</b> | <ul style="list-style-type: none"> <li>• 4Service Offshore AS</li> <li>• A/S Uglands Rederi</li> <li>• AAT Shipinvest AS</li> <li>• Archer Norge AS</li> <li>• Atlantic Offshore Management AS</li> <li>• Awilco AS</li> <li>• Blystad Group</li> <li>• Boa Offshore AS</li> <li>• Bourbon Offshore Norway AS</li> <li>• Buksér og Berging AS</li> <li>• CGG Services (Norway) AS</li> <li>• COG Offshore AS</li> <li>• DOF ASA</li> <li>• Eidesvik Offshore ASA</li> <li>• Esvagt Norge AS</li> <li>• Farstad Shipping ASA</li> <li>• Forland Shipping AS</li> <li>• Fred. Olsen Energy ASA</li> <li>• Fred. Olsen Ocean AS</li> <li>• GC Rieber Shipping AS</li> <li>• Golden Energy Offshore AS</li> <li>• Grieg Star Group AS</li> <li>• GulfMark AS</li> <li>• Hagland Shipping AS</li> <li>• Havila Shipping ASA</li> <li>• Island Offshore Management AS</li> <li>• K Line Offshore AS</li> <li>• Knutsen OAS Shipping AS</li> <li>• Maersk Drilling Norge AS</li> <li>• Maroff Crewing AS</li> <li>• Myklebusthaug Management AS</li> <li>• North Sea Shipping AS</li> </ul> | <ul style="list-style-type: none"> <li>• Norwegian Maritime Services A/S</li> <li>• O. H. Meling &amp; Co. AS</li> <li>• Ocean Installer AS</li> <li>• Oceanteam Shipping ASA</li> <li>• Odfjell Wind AS</li> <li>• Offshore Heavy Transport AS</li> <li>• Offshore Logistics AS</li> <li>• Olympic Shipping ASA</li> <li>• Østensjø Rederi AS</li> <li>• Prosafe AS</li> <li>• Reach subsea AS</li> <li>• Remøy Management AS</li> <li>• Remøy Shipping AS</li> <li>• Rolls-Royce Marine AS</li> <li>• Sea-Cargo AS</li> <li>• Shandong Twin Marine AS</li> <li>• Siem Offshore AS</li> <li>• Sigba AS</li> <li>• Simon Møkster Shipping AS</li> <li>• Sodexo Mobile Units AS</li> <li>• Solstad Offshore AS</li> <li>• Thome Ship Management Norway AS</li> <li>• Tor Husjord Management AS</li> <li>• Transocean Offshore North Sea</li> <li>• Tschudi Shipping Company AS</li> <li>• Uglund Construction AS</li> <li>• Uksnøy &amp; Co. A/S</li> <li>• Vestland Offshore</li> <li>• Volstad Maritime AS</li> <li>• Wilh. Wilhelmsen ASA</li> <li>• WindPartner AS</li> </ul> |
| <b>SITE INVESTIGATION</b>        | <ul style="list-style-type: none"> <li>• Norwegian Geotechnical Institute (NGI)</li> </ul>   |  |
| <b>SOFTWARE</b>                  | <ul style="list-style-type: none"> <li>• APIteq</li> <li>• EDR Medeso AS</li> <li>• ExproSoft AS</li> </ul>  | <ul style="list-style-type: none"> <li>• Kalkulo As</li> <li>• Kongsberg Digital AS</li> <li>• Promineo AS</li> </ul>  |

| SUPPLY AREA                      | SUPPLIER   |
|----------------------------------|--|
| <b>SUBSEA ENGINEERING</b>        | <ul style="list-style-type: none"> <li>Argus Remote Systems AS</li> <li>Csub AS</li> <li>Deep C Solutions AS</li> <li>Scanmudring AS</li> <li>Seløy Undervannsservice AS</li> <li>Stinger Technology AS</li> <li>Sub Sea Services AS</li> <li>Well Innovation AS</li> </ul>  |
| <b>SUBSTATIONS</b>               | <ul style="list-style-type: none"> <li>Aibel AS</li> <li>Kværner</li> </ul>  |
| <b>SUPPORT SERVICES</b>          | <ul style="list-style-type: none"> <li>Alloyance AS</li> <li>Bergen Group Aak AS</li> <li>Birken &amp; Co AS</li> <li>BSA Offshore AS</li> <li>Einar Øgrey Farsund AS</li> <li>FeC, Isdalstø</li> <li>Identec Solutions AS</li> <li>Marin Teknikk AS</li> <li>MARINTEK</li> <li>Metcentre</li> <li>Stadt Towing Tank AS</li> </ul> |
| <b>TRAINING</b>                  | <ul style="list-style-type: none"> <li>Ask Safety AS</li> <li>NSG Wind</li> </ul>  |
| <b>TURBINES</b>                  | <ul style="list-style-type: none"> <li>3b Fibreglass</li> <li>Devold AMT AS</li> <li>Norsetek AS</li> </ul>  |
| <b>VESSEL MANUFACTURE</b>        | <ul style="list-style-type: none"> <li>ESNA AS</li> <li>Fjellstrand AS</li> <li>Grovfjord Mek. Verksted AS</li> <li>Havyard Group AS</li> <li>Kleven Maritime AS</li> <li>Måløy Verft</li> <li>Ulstein verft AS</li> <li>Umoe Mandal AS</li> <li>Vard Group AS</li> </ul>  |
| <b>WAREHOUSING AND INVENTORY</b> | <ul style="list-style-type: none"> <li>Uniteam Group</li> </ul>  |



# PROMOTING NORWEGIAN ENERGY CAPABILITIES IN INTERNATIONAL MARKETS

## **Oslo**

Hoffsveien 23,  
NO-0275 Oslo  
Norway  
+47 22 06 14 80

P.O. Box 631 Skøyen,  
NO-0214 Oslo

## **Stavanger**

Prof. Olav Hanssensvei 7a  
NO-4068 Stavanger  
Norway  
+47 51 87 48 80

P.O.Box 8034  
NO-4068 Stavanger



**NORWEP@NORWEP.COM**  
**WWW.NORWEP.COM**