Norsk Industri

DELIVERY MODELS FOR OFFSHORE WIND

Delrapport – Drift, vedlikehold & modifikasjon
Operation, maintenance & modifications

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Preface

This report is produced as a part of the project delivery models for offshore wind as a summary and reflection of 25 different interviews performed in a working group towards operation, maintenance, and modification within offshore wind. The work has been both challenging and rewarding and could not have been performed without the contribution and support from all the companies which agreed to participate in an interview and share their experiences and reflections.

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Cover photo: Ørsted

Content

Sammendrag og anbefalinger

Det internasjonale drifts-, vedlikeholds- og modifikasjons-markedet i havvind er svært forskjellig fra hjemmemarkedet i olje og gass. Spesielt på turbinsiden har standardisering et høyt fokus for å holde kapitalkostnader nede.

Det er en forventet vekst på rundt 16 prosent år for år frem mot 2029 i det globale markedet for havvind, og på det samme tidspunktet er det en forventning i markedet at driftskostnader per MW skal ned med rundt 20 prosent.

Nedgangen i driftskostnader per MW er antatt å bli drevet av digital teknologi og fjerndrift, to områder hvor norske drift- og vedlikeholdsleverandører bør ha et konkurransefortrinn. Dette er støttet av funn fra gjennomførte intervjuer med utviklere og operatører i havvindmarkedet. Trenden ser ut til å være kortere varighet på vedlikeholdskontrakter for å kunne reforhandle rater tidlig, og en kostnadsmodell hvor vedlikeholdskostnader synker i løpet av varigheten til kontrakten er foretrukket. Hoveddrivere i vedlikeholdskontraktene er å oppnå høyest mulig produksjon fra parken til en lavest mulig kostnad.

Det er antatt at norske drift- og vedlikeholdsleverandører vil ha et konkurransefortrinn innenfor flere segmenter ved digital teknologi og fjerndrift, og det er observert at de norske drift- og vedlikeholdsleverandører som har lykkes inne havvind har utført en grundig markedsanalyse og forstår risiko og muligheter i markedet, samt at de har gått sammen i strategiske partnerskap og kan vise til et bidrag til lavere Levelized Cost of Energy (LCOE).

Funnene i denne rapporten er i tråd med funn i andre arbeidsstrømmer og analyser utført i prosjektet leveransemodeller for havvind.

Følgende anbefalinger er foreslått:

- Etablere forretningsplaner for hvordan å entre vedlikeholdsegmentet i havvindmarkedet. Dette må baseres på omfattende markedsanalyse hvor man forstår risiko og muligheter inn i markedet.
- Forstå bedriftens plassering i verdikjeden og nærhet til sluttbruker, profilere konkurransefortrinn og bidrag til å redusere LCOE.
- Utnytte erfaring fra offshore arbeid og marine operasjoner under krevende forhold.
- Etablere strategiske samarbeid, for å levere tjenester i større portefølje.
- Analysere hvordan din bedrifts produkter og tjenester kan tilpasses markedet, spesielt med fokus på å bidra til redusert LCOE.
- Evaluere og levere tjenester i en integrert verdikjede, dette kan for eksempel være at man tilbyr analysetjenester i tillegg til inspeksjonstjenester.
- Forstå og kartlegge bedriftens karbonfotavtrykk.

Summary and recommendations

The international operation, maintenance, and modification (OMM) market in offshore wind is highly different from the home OMM market in oil and gas.

At least on the turbine side standardization has a high focus in order to keep the CAPEX down. The overall OMM market for offshore wind is estimated to grow 16 percent per annum on a global level through 2029. At the same time there is an expectation for a decline in the average OPEX/MW to be about 20%.

The decline in OPEX/MW are believed to be driven by digital technologies and remote operation, where the Norwegian O&M suppliers should have a competitive edge. This is supported by the findings from interviews performed with operators in this market. The trend is short duration on the service maintenance contracts in order to be able to renegotiate the rate, and it would be beneficial if the O&M supplier would purpose a cost model which are declining over the duration of the contract. The main drivers in such contracts are to achieve a maximum of production from the asset with low cost.

It's believed that Norwegian O&M suppliers will have a competitive edge, and it is observed that the Norwegian O&M suppliers which have succeeded to enter the OMM market in the international offshore wind segment has done a comprehensive market intelligence and understands the risks and opportunities. Together with other factors such as strategic partnerships, and a contribution to lower LCOE.

These findings are in line with findings from the other workstreams and analyses performed within the project.

Bringing together the results from the interviews, a set of recommendations are proposed:

- Establish a sound business proposition based on comprehensive market intelligence and understand the risks and opportunities going into the offshore wind maintenance market.
- Understand the company's place in the value chain and proximity to the end user, market your competitive edge to the end user by how to reduce the LCOE.
- Utilize experience from offshore work and marine operations in harsh environment.
- Establish strategic partnership to deliver services in a larger portfolio.
- Analyse how to adapt your product and services for the offshore wind maintenance marked, with a focus on lowering LCOE.
- Evaluate to provide services in an integrated value chain. E.g., not only providing inspection services, but interpretation or analysis of such in addition.
- Understand and map your carbon footprint.

«To thrive in offshore wind, you must forget your legacy! This is a new game. Truly comprehend the market's needs. Redefine your deliveries and go to the market with a unique and sustainable value proposition that hits the operators supply chain midships! That is the savvy way to succeed!»

Kim B. Lindseth, CEO, On & Offshore Services AS

1 Introduction

BVG[1] associates define the OPEX value chain Operation, Maintenance and Services (OMS). The cost associated with OMS will vary dependant on the offshore wind farm setup and distance from shore. The OMS part will equal to about 30 percent of the total Levelized Cost of Energy (LCOE).

LCOE is used to evaluate and compare the cost of electricity production, usually measured in €/MWh or £/MWh for wind farm projects. LCOE is equal to the NPV (Net present value) of totals costs over lifetime divided by the NPV of electrical energy produced over lifetime. Thus, after completion of construction of the wind farm, the focus would be to keep or lower cost associated with OMS, and at the same time keep performance and availability high. The operations cost, including logistics equals to 33 percent of the OMS cost, where maintenance and services includes the remaining 67 percent of the OMS cost.

On a global market level Wood Mackenzie[2] expect a growth in the OMM market of 16 percent per annum through 2029, where the European OMM market will have the majority share reaching up to $6,6 billion by 2029. In 2020 terms that would put the European OMM market value to about £1,24 billion. As a comparison, the Norwegian Oil and Gas OPEX[3] is prognosed to be £5,25 billion and additional £2,90 billion in modifications of existing assets for 2021. The average global decline in OPEX/MW is expected to be about 20 percent between 2020 and 2029, mainly driven by:

- Flexible service operation vessels
- Remote operation innovations
- New digital technologies
  - Machine learning
  - Deep learning from data
  - Robotics and autonomous systems

PURPOSE

With reference to Delivery models offshore wind[4], NORWEP report: "Opportunities in offshore wind for the Norwegian supply chain", as well as the report "Norwegian opportunities in green electrical value chains"[5], the area of high tech or digital services to operation and maintenance is an area where the Norwegian industry is in a competitive position

Offshore wind farm. Photo: Wood

To investigate further into the subjects, this working group for Operation, Maintenance and Modifications is run as a part of project for opportunities within offshore wind. The working group's goal are:

- Map operation, maintenance and modification processes and players for offshore wind Europe
  - Including integrity management and life extension
- Evaluate trends with respect to roles and responsibility
- Map Norwegian supplier industry's ability to deliver services, e.g., monitoring, maintenance, optimal operation, and life extension.
- Establish an overview for the Norwegian Operation, Maintenance and Modification (OMM) industry to take a position within this segment.

1. BVG Associates, https://guidetoanoffshorewindfarm.com/wind-farm-costs, accessed 28.04.2021.
2. Smart Energy, https://www.smart-energy.com/renewable-energy/operations-and-maintenance-of-offshore-wind-farms-to-generate-12bn-per-annum-by-2029/, accessed 15.03.21
3. Norwegian Petroleum, https://www.norskpetroleum.no/en/economy/investments-operating-costs/, accessed 05.05.21.
4. E. Bjerknes, «Leveransemodeller for havvind, Norsk Industri, 2021.
5. I. Valstad, M. G. Viddal, K. Blindheim, H. H. Hersleth, K. Øren and T. B. Lossius, «Norske muligheter i grønne elektriske verdikjeder», NHO, 2020.

The goals are obtained through research of international developers and operators, as well as Norwegian suppliers' website and interviews conducted on Microsoft Teams according to fixed interview guides.

SELECTION

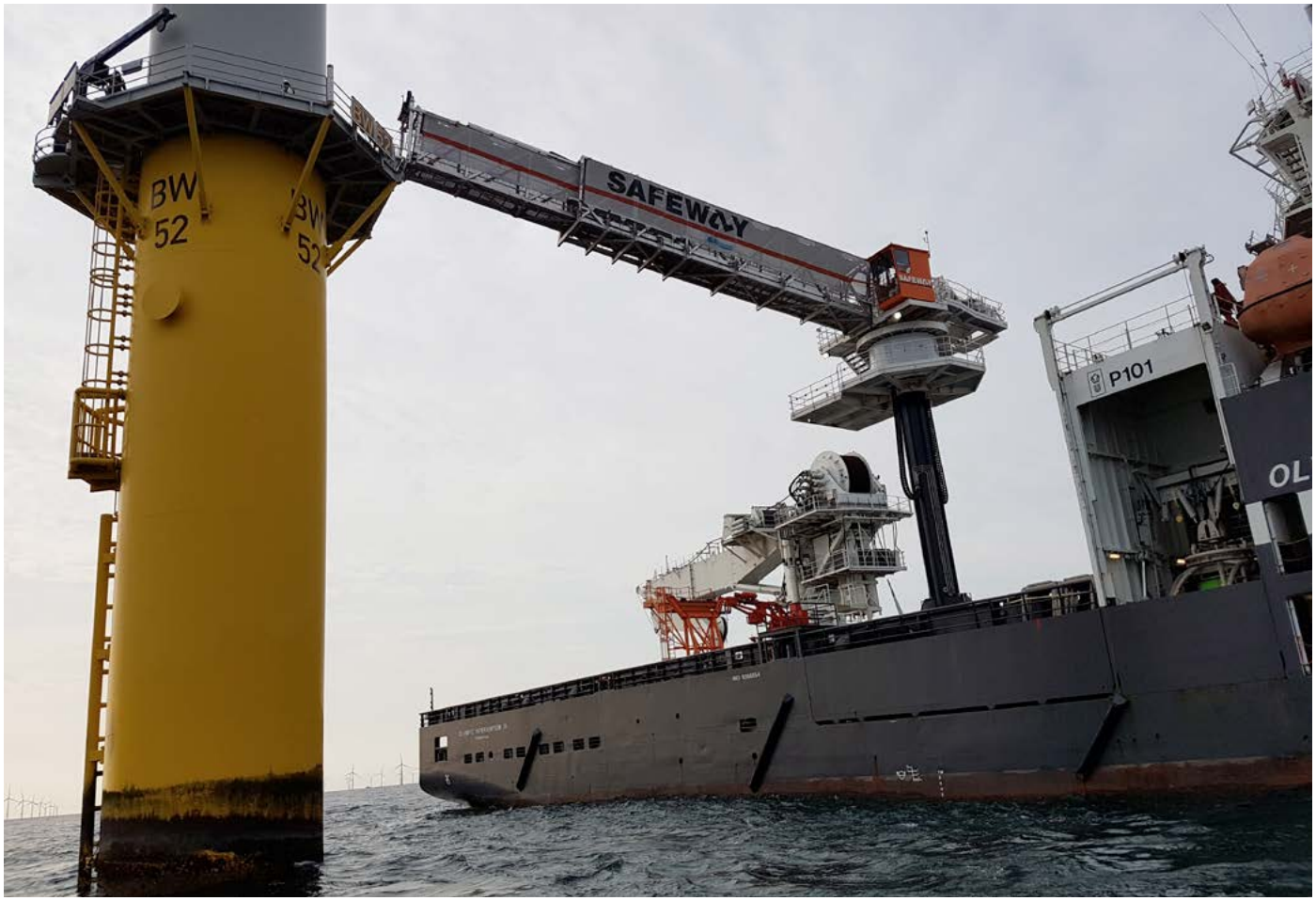
The selection of Norwegian suppliers is based on the survey performed by Technology and products[6]. In this report, where one fourth of the 338 Norwegian suppliers who provided input classified their company as a supplier within operation, maintenance, and services, 31 within Integrity management and lifetime extension.

From this list of companies' diverse portfolio of Norwegian suppliers within the categories Operation, Maintenance, and Services and Integrity Management and lifetime extension was selected and an interview was requested. The categories in the value chain are shown in Figure 1. Focus has been on the sub-categories of maintenance services and inspection services respectively, as well as monitoring, surveillance and analysis services and inspection services. The data gathered through the project is summarized and presented in this report.

Operation, Maintenance, and services is defined as the actual physical work performed. This could be both preventive actions on a firm schedule or corrective rapid response to repair.

Integrity management is considered as a large umbrella of services from planning to execution to keep facilities running optimal from both a technical and financial perspective. Companies within this sub-category is working closely with O&M providers and could even be responsible for subcontracting the O&M activities.

Vessels, and Training and certification as defined on the NORWEP value chain is not discussed in this report as these sub-categories are covered in working group for marine operations[7] in phase one and working group for mapping Norwegian competence environments within offshore wind[8].



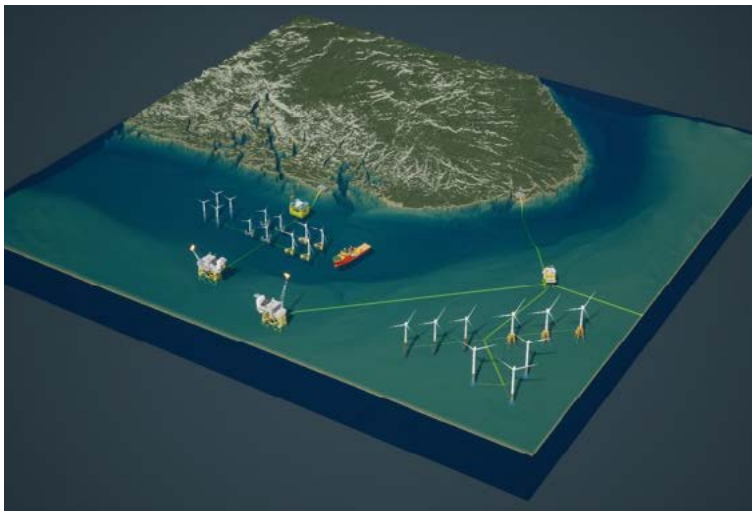
W2W Solution. Photo: Techano/Safeway

6. K.S. Andersen, E. H. Austrheim and A. Nesse, «Leveransemodeller for havvind – Delrapport – Teknologi og produkter», Norsk Industri, 2021.
7. J. Gutzkow, "Leveransemodeller for havvind – Delrapport – Marine operasjoner, Norsk Industri, 2021.
8. E. H. Austrheim and A. Nesse, «Leveransemodeller for havvind – Delrapport – Kompetansemiljøer», Norsk Industri, 2021.

Development	PM & Engineering	Turbine Supply	Balance of Plant	Installation	Commissioning	Operations, maintenance and services	Integrity management and life time extention	Decommissioning
Environmental surveys	Project management	Marshalling yards	Turbine foundations	Turbine installation	Commissioning services	Maintenance services	Monitoring	Port
Consenting and development services	Procurement	Marshalling ports	Transition piece	Foundation installation	Commissioning logistics	Inspection services	Surveillance and analyses services	Logistics
Establish basis for design	FEED and Detail Engineering	Assembly yard	Equipment for foundation and transition piece	Offshore and onshore cable installation	Commissioning port	Vessels	Inspection services	Marine operations
	Information management	Drive chain	Electrical cables	Offshore and onshore substation installation		O&M ports		Salvage and recycling
	Life cycle documentation (analyses)	Power conversions and supplies to the turbine and tower production	Electrical systems	Offshore HVDC installation		Training and certification		
			HVAC/HVDC topside	Installation port				
			Secondary steel work	Installation logistics				
			Mooring systems					

Figure 1: Framework based on NORWEP division of value chain[12]

For O&M ports BVG associates[9] states that historically ports have been within short distance to the wind farm. A move to Service Operation Vessels (SOV) and a few installations with offshore accommodation, this necessity has reduced and may allow for Norwegian ports to support foreign wind farms. However, for Doggerbank the O&M port is chosen as Port of Thyne[10], which in turn are within 100 nautical miles (185 km) even though a SOV solution is utilized. This observation supports BVG associates conclusion which is that O&M ports is a low opportunity for Norwegian supply chain because there is no home market. However, the report for Norwegian ports, yards, and construction sites for offshore wind[11] has mapped out 767 fishery-registered ports and harbours which might serve the purpose as O&M ports in Norway.



Offshore wind park[13]

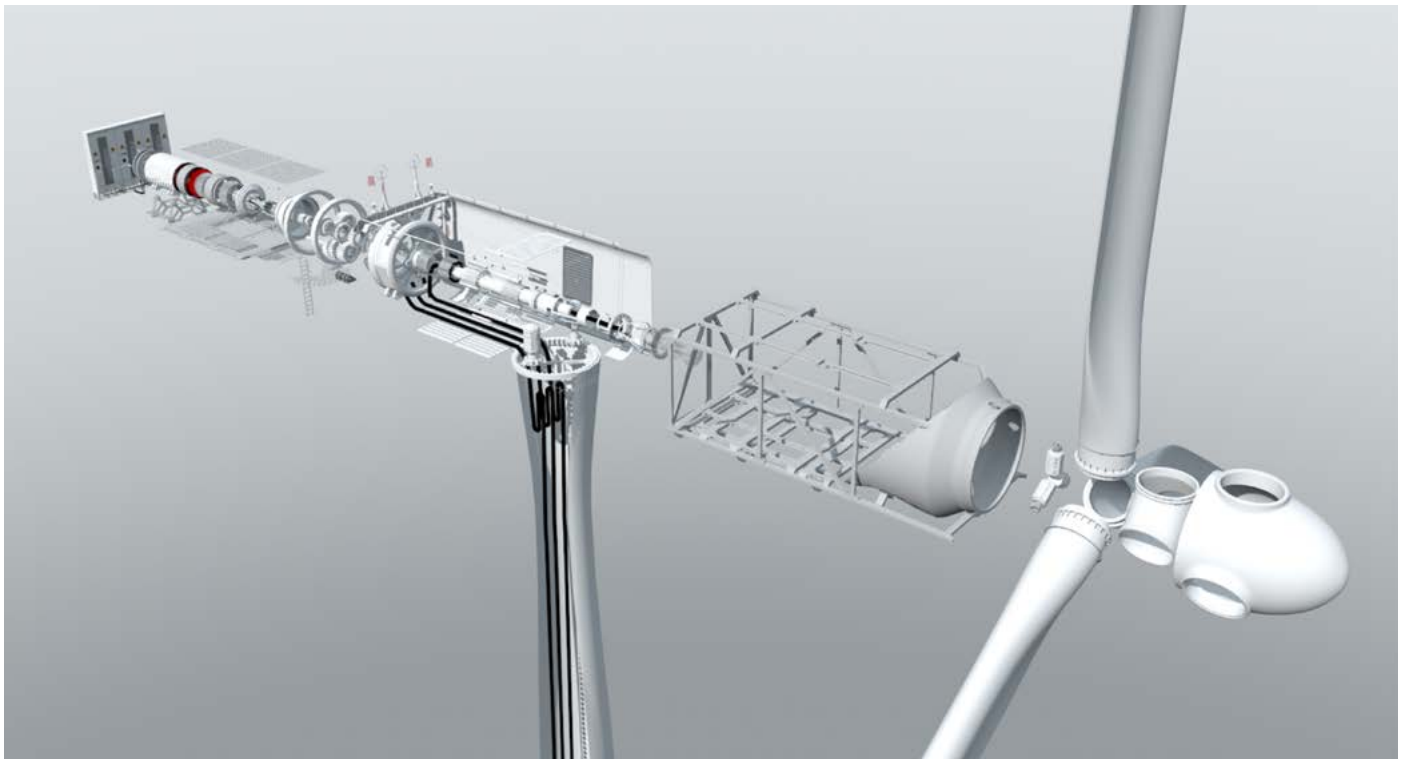
DISCLAIMER

This study is by no means exhaustive in mapping either the international developers or operators nor the Norwegian suppliers of operation and maintenance services. For this time being only a select small portion of the suppliers who replied to the questionnaire "Leveranse av teknologi, produkter og tjenester til havvind", has been invited to participate. The conclusions in this report are also based on information gathered in the process and may be based on incomplete or misunderstood information. A potential supplier or operator would thus be advised to seek further information independently of this report.

9. BVG Associates, « Opportunities in offshore wind for the Norwegian supply chain», NORWEP, 2019.
10. Equinor, https://www.equinor.com/no/news/20210325-dogger-bank-design-operations-maintenance-base.html, accessed 28.04.21
11. N. Indrevær, Leveransemodeller for havvind – Delrapport – Norsk havner, verft og byggesteder», Norsk Industri, 2021.
12. K.S. Andersen, E. H. Austrheim and A. Nesse, «Leveransemodeller for havvind – Delrapport – Teknologi og produkter», Norsk Industri, 2021.
13. E. Bjerknes, «Leveransemodeller for havvind – Delrapport – Innledning, sammendrag og leveransemodeller», Norsk Industri, 2021.

2 Maintenance of offshore wind parks

The offshore assets in an offshore wind park depends on the configuration of the wind park. This chapter gives a brief overview of the main assets and the equipment installed on the assets.



Wind Power Services. Photo:: IKM Elektro

A typical list could be[14]:

- Offshore wind turbines with foundations
- Inter array cables
- Offshore sub stations with foundations
- Export cables

Offshore wind turbine generators (WTG) typically consist of the following elements:

- Blades and Spinner
- Nacelle
  - Control system
  - Generator
  - Gearbox
  - Main shaft
  - Utility systems
- Tower
  - Personnel access
  - Material handling equipment
  - Electrical cables
- Transition piece
  - Crew access system and work platform
  - Davit crane
  - Power take-off
- Power take-off
- Foundations, monopile/jacket structure

14. BVG Associates, «Guide to an offshore wind farm», The Crown Estate, 2019.

HVDC Converter Station. Photo: Aibel

For offshore sub stations the equipment will vary dependant on the service, generally[15]:

- Helideck
- Transformers
- Reactors
- Converter valves (HVDC)
- Switchgear array
- Switchgear export
- Crane
- Generator, auxiliary or backup
- Platform control
- HVA/C
- Seawater lift pumps
- Cooling medium pumps
- Safety equipment
- Topside structure
- Foundations/Jacket structure

Services in the operation and maintenance segment could span from inspection and maintenance of assets, monitoring, surveillance and analysis services to ports and vessels.

For an offshore wind park, the majority of assets are the WTGs, the large volume will drive the maintenance hours. It is estimated that around 23 percent[16] of the failure events driving to maintenance of WTG are related to blade damage, recent studies have additionally shown that a low-to-moderate leading edge erosion damage may amount to a loss of 1–5percent[17] in annual energy production of a WTG. Provided the capacity factor of the example in 0,4471[18], this would span from 44,7GWh – 223,6GWh.

For this reason, turbine blades have the attention, a lot of initiatives are run, among other: Drone inspection for replacing traditional personnel inspection, computerized (machine learning) interpretation of drone photos, localized weather warning with the ambition of slowing down the speed of the WTG to avoid damage, enhancing materials used in the turbine blades and to vibration monitoring of turbine blades.

15. BVG Associates, «Global Offshore wind substation market outlook», NORWEP, 2020.
16. M. Florian and J.D. Sørensen. Wind Turbine Blade Life-Time Assessment Model for Preventive Planning of Operation and Maintenance
17. D. C. Maniaci, E. B. White, B. Wilcox, C. M. Langel, C. P. van Dam, and J. A. Paquette, 2016, Experimental measurement and CFD model development of thick wind turbine airfoils with leading edge erosion. Journal of Physics: Conference Series, 753, 022013
18. BVG Associates, https://guidetoanoffshorewindfarm.com/wind-farm-costs, accessed 28.04.2021.

The average global decline in OPEX/ MW is expected to be about 20 percent between 2020 and 2029.

3 Wind farm operators – Interview results

Interviews with wind farm developers and operators have been performed during the spring of 2021. The subjects have been on the drivers and motivation in service maintenance agreements as well as what services the operators are requiring. The results of these interviews are summarized in the following chapter.

CONTRACTS

The contract strategy for service maintenance agreements is amongst other affected by warranties. In some cases, it is required to sign a service maintenance agreement in order to have warranty on the asset, in other cases the assets warranty is less attractive due to the sheer size of the warranty is not large enough to be leveraged against the actual cost of an outage. The size of the operator's organization seems to play a major role for the position which are taking in this respect, larger organizations are more interested in having full control over the operation and maintenance parts themselves, as for smaller organizations there is a larger interest in outsourcing the operation and maintenance, thus the warranty is a more attractive contributor to the contract's strategy for service maintenance agreements.

The duration of contracts seems to be declining, depending on product maturity. Given technological step changes i.e., from gear driven turbine to gearless turbine, the warranty period will be important risk mitigation for operators. As there is a rapid evolvement in this market, it seems to be favourable to keep shorter durations to use the position to negotiate lower rates after a period. At the same time this could be used as an incentive into a tender for a service maintenance agreement if the supplier where to purpose a model where the rates are declining in a certain period. Thus, providing an incentive in the contract to enhance or optimize the maintenance performed.

Usually, service maintenance agreements are made with the supplier of the WTG to have warranty for the asset. Here the operator will use the warranty period, typically five years, where the WTG supplier has control, to educate their own technicians. This method ensures control over maintenance data and know-how when the operator is taking over after the warranty period ends. For substations there are several different regimes depending on the country which applies, e.g., in Germany the transmission system operator (TSO) is the developer of the offshore substation, and in the UK the substation is sold to an Offshore Transmission Owner (OFTO) after 18 months operation[19], thus a service maintenance agreement with the substation contractor as part as EPCI (Engineering Procurement, Construction, and Installation) has not been discussed in the same extent.

The operational part of the wind farm is the operator's responsibility and for all the operators we have talked with a key area kept in house. In some cases, the supplier in the other end of a service maintenance agreement is responsible for their own logistics, though the usual cases seem to be handled in one contract set out from the operator where the motivation is better price levels and internal control over the logistic optimization.

As discussed in the delivery models report[20], emergency preparedness is a bit different than on the Norwegian Continental Shelf (NCS). In UK first line is usually handled on field, but second line is centralized through Maritime and Coastguard Agency (MCA). This contrasts with the NCS where the operator has the responsibility of second line as well.

As there is a requirement for special education for wind turbine technicians and some operators prefer to keep the maintenance services for WTG in house, the standards seem to be not to leverage the service maintenance agreements across the offshore wind farm i.e. substations, WTG, and onshore plant.

Project financing prefer to minimize risk in the project and tra-

19. ModernPowerSystems, https://www.modernpowersystems.com/features/featureoffshore-transmission-the-licensing-regime-explained/, Accessed 28.04.21
20. E. Bjerknes, «Leveransemodeller for havvind – Delrapport – Innledning, sammendrag og leveransemodeller», Norsk Industri, 2021.

ditionally setting a service maintenance agreement to the WTG has been a risk mitigating measure compared to leaving this to the operator. Another factor here has off course been the warranty from the supplier. Though a trend is seen in the market where the operator has proved that this could be performed by themselves, thus reducing the need for a service maintenance agreement.

Development of local industry is more and more in focus when assigning licenses, though this differs from market to market. Service maintenance agreements and the operations and maintenance bases are excellent areas for building local industry and local workplaces. Usually, the operation and maintenance base are established as part of the wind farm development by the operator and serves one or several wind farm development projects, in other cases this is handled by maintenance service suppliers.

The main drivers in an effective service maintenance agreement are to achieve a maximum of production from the assets, thus performing maintenance when there is less wind, i.e., summertime. It is important to plan the maintenance well and have an optimal logistics schedule. This is one of the reasons why it seems to be interesting for the operators to have the control over both the logistical part and the maintenance planning part.

Typical parameters in such contracts could be both mobilisations. Warranties are usually measured against a guaranteed availability of an asset.

The contact point for the suppliers will differ dependant on the services or gods provided. Often the contact will be in the EPCI or system suppliers. Norwegian suppliers are in the international market aiming for a highly competitive market which will be hard to enter, though a lot of the oil and gas experience can be transferable, and the key to success for the suppliers are to provide unique products or services which contributes to a lower LCOE[21]. Specially within logistics there is a focus of reducing the carbon footprint. Some hybrid vessels are in operation today, but NH3 and H2 as well as all electric technology is interesting, and probably and edge for Norwegian supplier industry.

For utilizing new technology references and qualification of the technology is needed, a way to obtain both is through collaboration with research centres such as Offshore Renewable Energy (ORE) Catapult or MetCentre.

SERVICES

This is typically unmanned assets, and the intention is to be present as rare as possible. Maintenance intervals less than every sixth month is not viable. Every year or rarer would be

Walk to work
Photo: Fred. Olsen Windcarrier

21. E. Bjerknes, «Leveransemodeller for havvind», Norsk Industri, 2021.

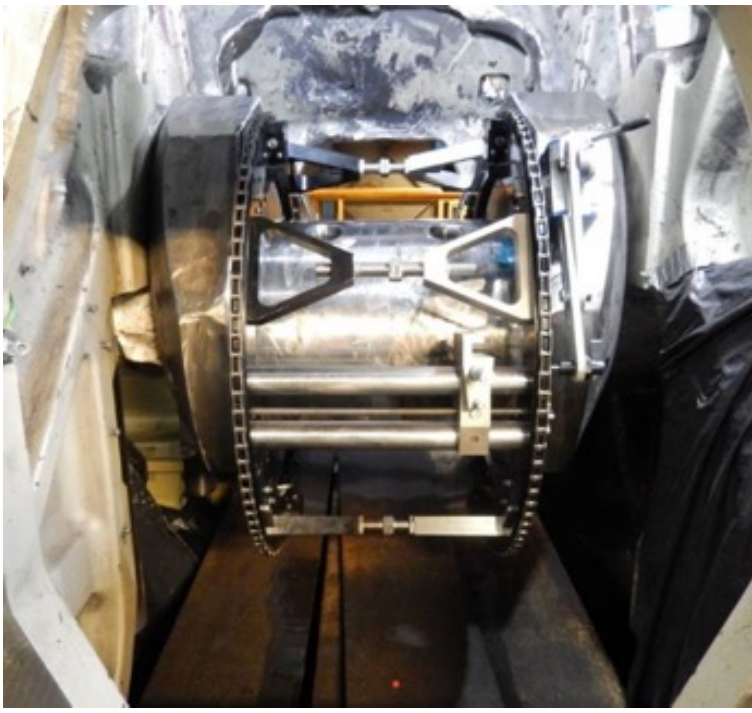
preferable, but off course some mandatory requirements could limit the campaigns. Typically, utilization of redundancy of equipment, condition monitoring and condition-based maintenance will make it possible to plan for maintenance campaigns in low production seasons such as summertime.

For some operators, which have their own personnel to preform maintenance, only low volume specialist services are set out to a supplier, and other tasks are performed in house. The split of such service portfolio differs from operator to operator, but inspection of the integrity of assets below surface are usually split from topside operation and maintenance.

A risk-based approach is utilized for inspections to increase the intervals. Typically, cables are inspected every second year. Foundation should be "maintenance and inspection"-free from design, though random samples of anodes are performed, not more often than every second year. Could be advantages here for making use of robotics in the future.

Services regards to maintenance planning are usually performed in-house. The operators wants to keep control and perform maintenance based on the entire wind parks performance. Special analytics services and software for analysing metocean data together with the condition of the entire wind park are interesting.

Life extension has a low focus in the development phase as the NPV will be low in the development phase. A potential life extension of a wind park is dependent on having a lease which makes it possible. Then it needs to be evaluated against the cost, but it is vital to have performed correct maintenance and gathered reliable data through monitoring or inspections to make this assessment in the late life of a wind park. A Potential life extension could be interesting both from governments and operators in order to keep up and boost the active production.



In-situ machining of shafts. Photo: QuantiServ

Development of local industry is more and more in focus when assigning licenses, though this differs from market to market.

Service maintenance agreements and the operations and maintenance bases are excellent areas for building local industry and local workplaces.

4 Suppliers for wind farms – Interview results

The overall objective of the project Delivery models offshore wind is to map the Norwegian supplier industry's feasibility in order to develop offshore wind on a larger scale on the Norwegian continental shelf.

And at the same time to map the industry's market position and competitiveness in the international market for offshore wind farms.

An analysis has been performed of the competitiveness[22] of the Norwegian supply chain against the emerging offshore wind market. The analysis was based on the Norwegian suppliers' market competence, experience, customer proximity, project maturity, international market potential and LCOE. The findings in this analysis are considered to be highly relevant for suppliers considering entering the market for offshore wind farms in general, including O&M players.

Based on the goals for the working group and the overall objective of the project, a diverse portfolio of Norwegian O&M suppliers has been interviewed to map what these companies may offer in terms of services and products, focusing on the OPEX phase of offshore wind installations.

SUPPLIERS MIX AND CHARACTERISTICS

The interviewed companies have confirmed that they have resources and capabilities that are relevant for the O&M and services segments in the offshore wind industry.

The supplier mixes in the group of companies interviewed is highly diverse. It is dominated by small and medium-sized companies, where more than 50 percent have 50 or fewer employees. About 15 percent have more than 500 employees[23].

The main features show that 60 percent of the companies are in service industries. Many of these are local companies that do not have a clear and viable potential for internationalization. There are few of the interviewed O&M suppliers that are categorized as tier 1 suppliers or product suppliers. The identified tier 1 suppliers tend to already deliver to the offshore wind industry, and the majority of these are considered to have the potential to deliver to the international market. For the identified tier 2 suppliers, approx. 50 percent are considered to have an international potential. These findings are in line with findings and conclusions in previous analyses of the entire value chain for offshore wind.

There is great variation in maturity towards the market for offshore wind among the interview objects. These variations make a big difference in how the individual supplier assesses and understands the operators' requirements and expectations related to contractual matters and the services provided.

One factor that has emerged in the survey is that many companies that now target offshore wind are coloured by a past in the oil service industry. For these companies, it is important to understand that offshore wind represents a completely new

«The experience and knowledge from collaborating with Equinor on the Hywind Scotland offshore wind park was crucial in order to win the top level SCADA contract on Dogger Bank A, B and C.»

Rune Reinertsen, Sales and Marketing Director, Origo Solutions

22. EH. Hundseid, «Leveransemodeller for havvind – Delrapport – Supply chain», Norsk Industri, 2021.
23. E. Bjerknes, «Leveransemodeller for havvind», Norsk Industri, 2021.

industry with different technologies, strategies, and economic drivers than what applies in oil and gas related industries. A fundamental understanding of this will lay down the premises for the individual company's competitiveness in the future.

At the same time, we have seen that companies that are founded on a focused business purpose of delivering products and services to offshore wind in general have a more profound and holistic understanding of the current market forces in offshore wind. The same applies to major tier 1 players who have been early adopters in this market.

SURVEY AND INTERVIEW RESULTS

Previous findings indicate that the offshore wind industry characteristics and strategic drivers are product- and services standardization, scalability, unique value proposition and as low LCOE as possible. During the O&M specific interviews our aim has been to clarify whether Norwegian O&M suppliers are aware of these market characteristics.

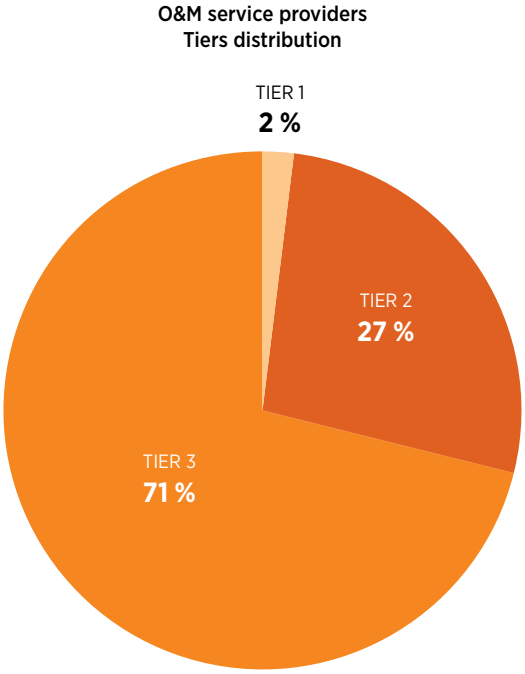
We have also had a special focus on clarifying whether Norwegian players take these factors into account to a sufficient degree when preparing their own strategies for penetrating this new and demanding market scenario.

Prior to the interviews, the suppliers were asked if they provide services and products to the offshore wind industry today. And if not, if they have ambitions to make such deliveries.

As many as 59 percent[24] of the relevant respondents answered positively that they deliver to offshore wind today. This number is surprisingly high when we consider that there are currently no other activities going on the NCS than Hywind Tampen. However, there are a lot of activities ongoing among suppliers to develop and make their products fit for the wind industry. Many companies are involved especially in ongoing UK projects that can support this high figure.

> *«Offshore Wind is an emerging market, yet we bring our pedigree from the traditional offshore business, by cross-over technology – utilized with the understanding of the key requirements of Offshore Wind Operators»*
>
> Øystein Bondevik, Business Development/ Sales Director, Techano AS

As implied above, in the identified group of companies that supply to the industry today, it is a few large tier 1 companies that clearly dominate the picture. As expected, tier 2 and tier 3 companies follow successively. The reason for this is that the tier 1 group was early in penetrating and adopting the market for offshore wind. Some of these companies have been in the industry for more than 10 years, and especially the major players have been able to transform their resources and capabilities from the oil and gas industry to offshore wind.



Tier distribution – O&M service providers (Total companies 52)

For smaller companies that have succeeded to penetrate the market, it is particularly highly specialized competence or a particularly unique value proposition that has been decisive in gaining a competitive advantage.

Companies that are responding negatively to their participation in the wind industry today, are all saying that they have ambitions to deliver equipment and services in the future.

The interviews were conducted as informal discussions with the suppliers. A questionnaire was used as a guide during the interviews.

The topics discussed were related to expectations of contractual relationships with operators within offshore wind and, which

24. H. Hundseid, «Leveransemodeller for havvind – Delrapport – Supply chain», Norsk Industri, 2021.

services that are to be delivered by the interviewees. Other factors such as the suppliers' resources, capabilities and value proposition were also addressed during the interviews.

CONTRACTS

Some questions were raised about contractual matters:

- What kind of service agreements will you offer?
- What do you want the agreement to cover?
- What kind of service model do you want to offer?
- At what stage of the wind farm's life span is it relevant to enter into an agreement with the operator?

In the following the feedback is summarized and discussed.

In terms of strategies and expectations for contractual matters, the feedback is as varied as the mix of suppliers in the survey. The answers and feedback are characterized by the various companies' background and maturity towards the offshore wind market.

For early adopters such as large tier 1 suppliers and companies with a reason for being clearly aimed at offshore wind, we find that the companies better understand the operators' expectations and requirements. By that we mean that the suppliers understand the customer's value chain and clearly see their position here. It can be implicitly put that these suppliers have a value proposition that meets the operators' needs and expectations. These factors characterize the feedback we have received about the type of service agreements offered by these players.

Agreements offered by companies that already have adopted the market are thus better adapted to special requirements from the industry related to the life span of the contract and the distribution of risk. Compared to oil and gas and other traditional industries, the agreements in this market tend to have a shorter duration, and at the same time higher requirements for suppliers to specifically contribute to reduced life span costs for the wind farms in general. The reason for these requirements is that LCOE is central in whether the individual installation is viable or not. This has been noticed and understood by most early adopters in their contract strategies, and thus they have an edge over the challengers.

When it comes to players who have not yet entered this market, a slightly different picture emerges. Several of the interviewees, especially tier 2 and 3 suppliers, tend to want to offer their services based on standard contracts and models for agreements used in deliveries to the oil and gas industry related to the NCS. It is important that such suppliers adapt to the operators' needs and requirements by offering and/or accepting changed contractual conditions.

It was also discussed with the suppliers what kind of delivery model is offered, as well as the scope of the delivery. Answers to these questions vary depending on the size of the provider and the type of services to be provided. Regarding service areas, we have in this study concentrated our efforts on integrity management, lifetime extension and more traditional operation and maintenance.

For suppliers who want to provide traditional operations and maintenance services, we see that it is largely the suppliers' strategy to offer services for the entire or larger parts of the wind farm. This coincides well with the operator's strategies for economies of scale and optimization in relation to cost-effective execution.

However, it is a significant challenge for O&M suppliers that the larger operators themselves have built up internal organizations for O&M. And we have received feedback from the operators and owners of the wind farms that this trend of insourcing will continue in the future. The expectation is that players with a background from the oil and gas industry tend to be too cost-intensive in the long run, and thus cannot compete effectively in this market. These factors become particularly apparent on bottom-mounted installations. The picture is somewhat different when it comes to floating offshore wind parks. In such scenarios, it is conceivable that experience from marine

Offshore wind farm. Photo: Wood

operations under harsh conditions will improve the competitiveness of players with a background in oil and gas. In such cases, it is also conceivable that an adoption of contract and delivery models from oil and gas to a certain extent may be transformed into this market.

For suppliers who are more focused on lifetime extension and integrity management, a strategy to provide services to larger parts of the wind farm is communicated as well as for more traditional O&M suppliers. At the same time, it tends to be smaller businesses with specialists who have established themselves in this part of the market by now. Such players will have problems being able to relate to the risk and responsibility mitigation that comes with the contract conditions for major deliveries within offshore wind. The delivery and contract model for such suppliers is therefore characterized by the fact that the assignments tend to be smaller and time-limited projects.

SERVICES

As previously discussed, the supplier industry which springs from oil and gas, will face challenges and barriers when it comes to penetrating the market for offshore wind. They will meet a considerable task when competing against established and strategic savvy players who have already gained a foothold in offshore winds. It is clear from the market analysis performed in phase one[25] that Norwegian O&M has low market competence and competitiveness today.

However, traditional Norwegian O&M suppliers have a lot of experience from the oil and gas industry that is transferable to both bottom fixed and floating wind farms, and we believe Norwegian suppliers can compete and win contracts provided they do good market research, and thereby gain a profound understanding the operators' needs and the competitiveness that characterizes this market.

	Total score	Konkurransekraft	Antall registrerte selskap	Har svart på undersøkelse	Internasjonalt potensial
Tier 1 HVAC, HVDC, kabel (EPC)	5,9	Meget høy	25	25	8
Produktleverandør Fundament bunnfast Tier 1-3	2,7	Lav	19	19	2
Produktleverandør Fundament flytende inkl. forankring Tier 1-3	3,5	Lav	13	13	5
Produktleverandør Utstyr Tier 2	5,1	Høy	47	20	30
Produktleverandør Utstyr Tier 3	4,0	Verken høy eller lav	115	64	57
Marine operatører Installasjon/sjøtransport/logistikk Tier 1-3	4,9	Høy	79	41	23
Havner og sammenstillingsverft	3,3	Lav	13	9	4
Skipsverft	5,3	Høy	12	7	9
Drifts- og vedlikeholdsleverandører inkl. levetidsforlengelse og integrity management tier 1-3	2,8	Lav	52	36	5
Engineering & konsulentselskaper testsentere og digitale tjenester	4,3	Verken høy eller lav	146	83	20

1 Svært lav 2 Meget lav 3 Lav 4 Verken høy eller lav 5 Høy 6 Meget høy 7 Svært høy

25. H. Hundseid, «Leveransemodeller for havvind – Delrapport – Supply chain», Norsk Industri, 2021.

Further to the above, we have during our inquiries found that O&M activities which are not part of the prescheduled maintenance schemes are likely to be outsourced to subcontractors.

The need for such operations often arises in the event of e.g., extreme weather or unforeseen technical problems. Such cases often require support from highly specialized professional suppliers that can meet the relevant issues at short notice. Especially for floating installations, suppliers from the oil and gas industry are positioned to offer competitive and viable services. Such services can typically be ROV inspections, surface inspections or other services that requires demanding maritime operations.

Furthermore, the presentation of results from inspections in the form of reports where collected data has been analysed and processed is an area where Norwegian suppliers may have a competitive advantage - based on the experience they have from offshore industries. This also provides a unique opportunity for the same suppliers to repetitively be inquired to be able to compare results from several operations.

The O&M segment has a significant share of the total mapped current Norwegian deliveries to offshore wind. These deliveries tend to have a high maturity that seems to have largely been developed through oil and gas operations. Many companies offer and deliver operation and maintenance on their own products, while a few of the deliveries are pure maintenance services aimed at the wind farm itself.

40 percent of the deliveries fall under maintenance services, 29 percent under vessels and 19 percent under inspection services. The remaining 12 percent is allocated to ports and training and certification services. Many equipment suppliers with deliveries to vessels used for maintenance have categorized these here.

Even though we find examples of O&M deliveries that are characterized by high maturity in our study, O&M suppliers that spring from oil and gas tell of significant challenges and barriers when they are to penetrate the market for offshore wind. They experience it as a tough task when they must compete against established and strategic savvy players who have already gained a foothold in the industry. However, Norwegian suppliers have a lot of experience from the oil and gas industry, which many believe is transferable to floating wind farms. And based on the findings of our study, we also believe that Norwegian suppliers can win many of the contracts provided they do a good job of understanding the operators' needs, understanding the competitiveness that works in the market and adapt accordingly.

Many of the services categorized as O&M in this survey are aimed at various special vessels used in the installation, operation, and maintenance of offshore wind farms. These services are characterized by a high degree of maturity. The reason is the Norwegian traditions for shipping and operational, maritime services.

Optimization of operations, integrity management and lifetime extension for offshore wind are business areas that have different characteristics than traditional O&M services. Norwegian suppliers providing services within these business areas have reported deliveries for monitoring (44 percent), inspection services (41 percent) and monitoring and analysis services (15 percent)[26]. The comments from the suppliers show some overlap in the deliveries to these three subcategories, which mainly consist of sensor technology, software and associated analysis and simulation services. Technology, products, and services in this category apply to complex deliveries ranging from pure inspection and monitoring assignments to data analysis. Such services are expected to be able to provide Norwegian suppliers with income throughout the life span of the parks, including in the international market. The solutions offered are to a large extent considered to be challengers in the market, and most solutions are at low to moderate maturity levels.

There is an understanding in the market that large OEM suppliers control the market for maintenance of turbine generators in the phase of development that offshore wind is currently in. These players also rely heavily on access to data from their installed product portfolio. This is a major challenge for technology companies that have developed solutions for monitoring and optimization. The challenge lies in the lack of access to data. Both operators and suppliers consider this to be proble-

«Many are reluctant to share data, given the high value of it. However, sharing the data is often required in order to realize the value of it.»

Petter Reistad, Project Manager, Cognite

26. K.S. Andersen, E. H. Austrheim and A. Nesse, «Leveransemodeller for havvind – Delrapport – Teknologi og produkter», Norsk Industri, 2021.

matic. It is assumed that the operators will in the long run push the OEM suppliers to more open access to data

In the subcategory «training and certification» we find a handful of players who offer both technical and safety GWO courses, as well as some suppliers who deliver courses on their own deliveries. Included in the subcategory «operating and maintenance ports» are some port facilities for service and maintenance bases, some equipment suppliers that supply measuring equipment and sensors, as well as catering / catering deliveries. However, the business area is currently considered to be relatively small. The reason is assumed to be that wind power on the NCS is currently underdeveloped, at the same time as the market has not yet been regulated in a good way.

VALUE PROPOSITION AND MARKET POSITION

The O&M segment accounts for 43 percent[27] of the estimated total cost over the life span of an offshore wind farm. Many Norwegian suppliers assume to be well positioned in maintenance and inspection and transport of personnel, which make up 70 percent of this segment. However, interviews conducted with suppliers that are already in this market indicate that this is optimistic as significant parts of the maintenance are, and will be, performed by the turbine supplier (OEM) with local personnel. Signals from operating companies further substantiate that operation and maintenance of substations will to a large extent be carried out by local personnel from inhouse resources and companies that serve the individual parks.

To meet the challenges mentioned above and succeed in the global O&M market for offshore wind, potential for internationalization and a unique value proposition have been identified as critical success factors.

Regarding internationalization, the individual player's potential in the form of financial strength and access to necessary resources and capabilities is crucial. We have found that more than half of the suppliers participating in this survey have 50 or fewer employees[28]. Most of these companies also have limited financial strength, and most of them are not represented with offices in other countries where the key markets tend to be. Such companies are likely to experience limited opportunities to build up local content through international deliveries, thereby weakening their competitiveness. One way to meet these barriers may be to seek alliances with companies and institutions that have the necessary resources and capabilities to meet the operators' expectations and requirements.

To take a position in the O&M market for offshore wind, one must have a unique and sustainable value proposition, and this must be communicated to the operators in a good way.

In our conversations with suppliers, we find that risk reduction and mitigation through relevant offshore experience may be a good foundation for competitiveness. At the same time, suppliers are apparently strong in tasks ranging from the use of digital tools, data collection and data processing to more traditional O&M tasks and maritime operations under challenging conditions. Despite these strengths, we find that with direct questions about what their unique value proposition is, many do not have clear answers. This indicates that many suppliers are not conscious enough of their own strengths, and that they have not understood the operators' expectations and requirements for a unique value proposition. If this is the case, it will be a threat to their future market success. The solution is to get to know the customers supply chain and develop a business strategy that meets the customer's requirements and expectations.

27. BVG Associates, «Opportunities in offshore wind for the Norwegian supply chain», NORWEP, 2019.
28. H. Hundseid, «Leveransemodeller for havvind – Delrapport – Supply chain», Norsk Industri, 2021.

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Abbreviations

EPCI	Engineering Procurement, Construction, and Installation
HVA/C	Heating, Ventilation and Air Conditioning
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
LCC	Life Cycle Cost
LCOE	Levelized Cost of Energy
MCA	Maritime and Coastguard Agency
NCS	Norwegian Continental Shelf
NORWEP	Norwegian Energy Partners
NPV	Net present value
O&M	Operations and Maintenance
OFTO	Offshore Transmission Owner
OMS	Operation, Maintenance and Services
OPEX	Operating expenditures
SOV	Service Operation Vessel
TSO	Transmission System Operator
WTG	Wind Turbine Generators

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