Offshore Wind Projects – Evolving Dynamics

Greater Challenges Than Onshore Peers, but Investment Grade Possible

Special Report

Differences From Onshore Projects: The key factors differentiating offshore wind projects from onshore ones include greater completion risk, more complex operations and the risk of failure in the offshore transmission cables, Fitch Ratings believes.

Construction Complex but Manageable: Completion risk for offshore wind projects is materially higher than for onshore peers and akin to that of thermal power and oil & gas projects. However, the industry is gaining experience and the observed reduction in the number of contracts under which projects are developed is positive. Key factors mitigating completion risk are experienced and financially strong sponsors and contractors, minimisation of interface risk, conservatism in construction schedules and the inclusion of sizeable contingency funds.

More Stable Energy Production: Stronger wind speeds offshore result in higher and more stable generation per megawatt compared with onshore projects, with estimated capacity factors averaging 45% compared with 33% for Fitch-rated onshore wind projects. Fitch understands that simpler topography reduces some of the uncertainties in offshore production estimates while wake losses are more difficult to estimate due to the larger size of arrays and projects.

Complex Logistics, Lumpier Operating Profiles: The more challenging operating environment and potentially longer unavailability periods may lead to lumpier operating and cost profiles for offshore projects. Dependency on vessels to transport personnel, equipment and perform maintenance is a key differentiating factor that, if not adequately managed, may result in material deviations from budgets. Long-term operating cost estimates in offshore projects average around EUR120,000 per MW, about double the cost for onshore peers.

The key factors driving Fitch's assessment of operating risk are the project's location, the operation and management (O&M) set up (eg counterparty, scope of services, term, and guarantees), the technology used and the project's technical design and scope.

Technology Evolution Increases Risk: The use of technology with long track record does not expose offshore wind projects to much greater performance risk compared with onshore, in Fitch's view. However the technology is evolving, particularly in bigger turbine sizes and new foundation designs. Ratings are likely to be constrained to sub-investment grade when technologies employed have no or very limited track record, unless appropriate warranties and performance guarantees are provided by investment-grade (IG) manufacturers.

Single Points of Failure Risk: The impact of failures of the key balance-of-plant equipment such as subsea cables or offshore transformers depends on project's technical redundancy, regulatory provisions, insurance and debt structure features. The exposure to the risk of subsea cable failures varies in different countries depending on the regulatory set-up.

Investment Grade Possible: Financial metrics thresholds for achieving IG ratings for operational offshore wind projects are the same as for onshore peers, subject to harsher stresses on availability and O&M costs and greater focus on breakeven analysis. In the absence of rating constraints such as revenue counterparty or technology, operational offshore wind projects can achieve IG ratings. Achieving IG for projects in construction is less likely, but is possible if interface risk is minimized and contractors are experienced and financially strong.

Related Research

WindMW GmbH (Meerwind) – New Issue Report (January 2016)

Wind Projects: High Risk of Production Shortfalls (June 2014)

Construction Risk of Offshore Wind Farms (May 2012)

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Completion Risk

Complex Construction Process

In the report *Construction Risk in Offshore Wind Farms,* 23 May 2012, Fitch discussed how the challenges of offshore construction and the involvement of numerous contractors with no single-point responsibility were the primary concerns leading to a sub-investment-grade assessment of the typical offshore wind projects under construction.

Positive Gradual Shift Away from Multi-Contracting

In recent years, there has been a trend towards a reduction in the number of construction contracts under which projects are developed. Large companies with marine engineering and construction experience are willing to take larger responsibilities under contracts with increasingly comprehensive scope of work. Some projects are being built under two engineering procurement and construction (EPC) contracts only (i.e. turbine supply agreement and Balance-of-Plant[1] (BoP) contract in line with the construction packages for onshore projects.

The reduction in the number of direct construction contractors is a positive development mitigating completion risk. Concentrating the responsibility for works with fewer contractors facilitates better management of the construction process and reduces credit exposure to smaller and often financially weak counterparties.

Focus on Contractor Financial Strength and Ease of Replacement

Fitch's approach to analyzing a project's exposure to completion risk is more widely discussed in Fitch's *Rating Criteria for Infrastructure and Project Finance,* September 2015. Completion risk analysis is performed separately for each material contract. The weakest of such assessments is likely to drive the rating during the construction phase.

The reduction of interface risk via the minimisation of the parties involved – coupled with solid contractual features for the allocation of risks and responsibilities – may lead to a 'Midrange' assessment of contract terms and, therefore, to the possibility of an investment-grade rating on the debt financing a project's construction.

On the other hand, replacing a wind turbine supplier or a contractor involved in the BoP works for an offshore wind project in all likelihood would be difficult because of the highly specialized technology, narrower pool of potential replacement contractors, and a longer lead time for their engagement.

These considerations are likely to lead, typically, to a 'Weaker' assessment of contractor replacement for offshore wind power projects. This implies that the projects' ratings during construction are likely to be constrained by the rating of the weakest contractor if there are no completion guarantees from the sponsors or other strong mitigating features.

Figure 1 shows the steps in Fitch's completion risk analysis applied to hypothetical offshore wind projects. Case 1 refers to a hypothetical project developed under a two-contract structure with a turbine supply agreement with an 'A'-rated manufacturer, a BoP agreement with a 'BBB-'-rated contractor and an interface agreement among the two contractors and the project company. Case 2 refers to a hypothetical project developed under a five-contract structure, with separate contracts for turbines, foundations, transmission cable, electrical infrastructure and vessel provision and installation services.

Related Criteria

Rating Criteria for Wind Projects (March 2016)

Rating Criteria for Infrastructure and Project Finance (September 2015)

[1] Balance of Plant refers to all components of a wind project other than the wind turbine. In case of an offshore wind project, BoP includes foundations, offshore and onshore substation, offshore and onshore transmission cables.

Figure 1
Completion Risk Framework – Examples

	Assessment	Rating Implication
Qualitative assessments		
Complexity & scale	**Weaker for both Case 1 and Case 2:** Large scale, high complexity, offshore location.	Constrained to higher of sub investment grade or contractor/credit enhancement combination.
Contractor expertise and implementation plan	**Midrange for both Case 1 and Case 2:** Contractors and suppliers with track record, time budget and cost budget appropriate to withstand moderate downside scenarios in the challenging offshore weather conditions.	Constrained to higher of 'BBB' category or to contractor/credit enhancement combination.
Contractor replacement	**Weaker for Case 1 and Case 2:** Specialised technology, very few alternative contractors available, timing/interface constraints.	Constrained to contractor rating.
Contract terms	**Midrange for Case 1:** Interface risk exists, but adequately mitigated by two contracts structure and robust interface agreement. **Weaker for Case 2:** Multi-contracting structure, significant interface risk.	**Case 1:** Higher of: (1) guarantor rating or (2) up to two categories above contractor rating. **Case 2:** Constrained to sub investment grade.
Contractor rating & credit enhancement		
Contractor rating category	**Case 1:** 'A' – turbine supplier; 'BBB-' – BoP contractor. **Case 2:** 5 different contractors of varying credit quality ranging from 'B' to 'A'.	
Credit enhancement	**Case 1 and 2:** 20% (Budget contingency, performance bonds) – assumed to provide reasonable margin over 24-36-month replacement horizon	
Achievable project debt rating category for completion phase	**Case 1: 'BBB-'** **Case 2: 'B'**	Constrained to the rating of the weakest contractor due to weaker 'contractor replacement' assessment.

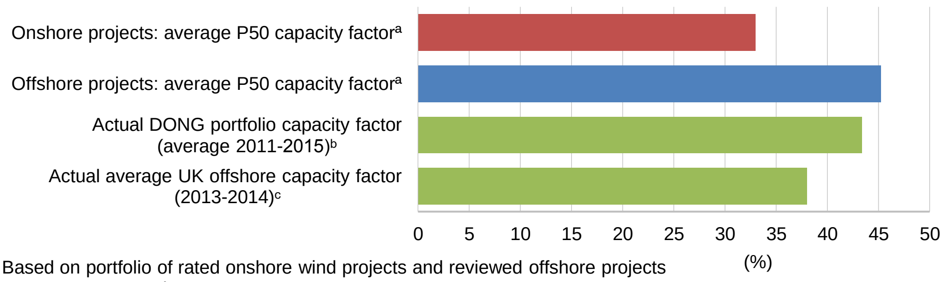
Source: Based on Rating Criteria for Infrastructure and Project Finance

Revenue risk – Volume

Stronger Wind

Wind speeds are typically higher and more consistent offshore, generating more electricity from each MW of installed capacity compared with onshore projects. In the offshore wind projects reviewed by Fitch, P50 capacity factors ranged from 39% to as high as 52% with the average of 45%. In contrast, in our portfolio of rated onshore projects, P50 capacity factors range from 21% to 51% with an average of 33%.

Figure 2
Onshore vs. Offshore Capacity Factors



[a] Based on portfolio of rated onshore wind projects and reviewed offshore projects
[b] DONG 2015 Annual report
[c] The Crowne Estate Wind Operational report 2015
Source: Fitch

Wind Data Quality

Estimating the wind resource for offshore projects follows the same approach as for onshore ones. Forecasts developed by technical advisors typically start from a gross production estimate based on the extrapolation of available wind data. Fitch understands that the lack of onsite measurements is not a material weakness for offshore wind projects. Given the absence of topography offshore, measurements from a met mast can be considered representative of a much larger area than is the case with onshore sites. More recent offshore wind projects may also employ floating LIDAR-technology buoys for measuring data on wind speed, wind direction and turbulence, which improves the quality of the collected wind data. Availability of actual operating data and forecasts by multiple experts provide comfort on their accuracy.

Gross Production Estimate Less

- Wake losses (internal and external)
- Turbine availability losses
- BoP availability losses
- Grid availability losses
- Weather downtime/accessibility losses
- Electrical efficiency losses
- Blade contamination/degradation losses
- Wind hysteresis (shut-down in high wind speeds)
- Other minor losses

= Net Production Estimate

Adjustment for Wake and Other Losses

Gross production estimates are adjusted for several loss factors, such as wake losses (internal and external), turbine availability and BoP/grid availability losses, weather downtime, electrical efficiency, blade contamination/degradation and several other minor adjustments. Fitch has observed that total losses can range from 16% to 23% of the gross P50 energy production estimate. Wake losses (the loss of wind speed due to the presence of other wind turbines within a project site or due to other nearby wind projects) are the largest component of total losses. Turbine unavailability is typically the second-largest loss component.

We understand from independent technical advisors that internal wake loss modelling is more difficult for an offshore project compared with an onshore plant since arrays are larger, and wake losses are increased due the size of the projects. However, improvements in the modelling techniques advanced in the past few years, with more precision in estimating wake losses, according to technical advisors. Estimating external wake losses may also be difficult as potential future nearby offshore wind projects may not have been built yet. In cases when there are proposed nearby wind projects, but uncertainties about the timing of their construction, the agency will rely on more conservative loss estimates that incorporate the impact of all planned wind projects.

Lower Uncertainty Than Onshore

The uncertainty of energy production estimates is typically lower for offshore wind projects compared with onshore peers. This is primarily due to lower uncertainty in the energy yield curve due to stronger and more consistent wind, despite the uncertainty of the wake losses possibly being higher. The lower overall uncertainty is reflected in the differential between P50 and 1yP90 estimates. This difference ranges from 8.5% to 12.8% in the offshore projects that Fitch has reviewed. For single-site onshore wind farm projects with no operating history, this ranges from 11% to 21%, with an average of 15% across Fitch's portfolio of single-site onshore wind projects.

Limited Performance Data

Fitch's experience with the performance of onshore wind projects indicates a general underperformance versus initial expectations. Across a portfolio of 19 rated onshore wind farms and 75 observational years, average production during 2005-2013 was 9.7% below P50 and 3.7% above 1yP90 (see '*Wind Projects: High Risk of Production Shortfalls*', June 2014). The agency does not yet have similar performance data for offshore projects. Some elements suggest that estimating production offshore is more straightforward due to simpler topography and lower wind uncertainty. At the same time wake losses may be more difficult to estimate. Fitch will continue to apply the more conservative 1yP90 production estimate in our rating case for both onshore and offshore wind projects.

Operation Risk

Lumpier Profile Expected

Fitch expects offshore wind projects to have lumpier availability and operating cost profiles compared with onshore projects. This may be the result of longer unavailability periods as bad weather delays repair works or merely reflects the challenging operating conditions. This exposure is addressed through more conservative assumptions for availability and operating costs compared to typical stresses applied to onshore wind projects and tested through dedicated breakeven analysis.

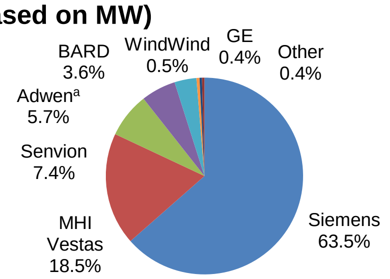
The technology used and the technical design and scope of the project, as well as the location, accessibility and O&M arrangements will determine Fitch's view on the operating risk of a specific project.

Technology Used

Fitch will review to what extent technologies for the main equipment (wind turbines, foundations, cables) is proven and tested. The financial strength of the equipment suppliers will also be assessed. Offshore wind projects that Fitch reviewed so far included proven and tested technology.

Figure 3

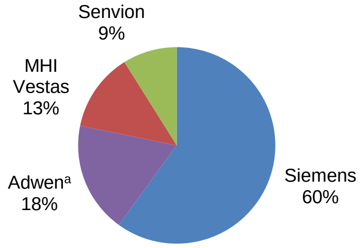
Cumulative Market Share in Europe (Based on MW)



[a] JV between Gamesa and AREVA
Source: EWEA

Figure 4

2015 European Installations (Based on MW)



[a] JV between Gamesa and AREVA
Source: EWEA

Increasing Capacity

The average offshore wind turbine size employed in the industry is growing, with 4.2MW on average installations in 2015, a 13% increase over 2014[2]. This is due to the increased deployment of 4-6MW turbines, expected to be followed by the gradual introduction of 6-8MW turbines towards 2018.

Evaluating New Technologies

Bigger turbine models will be new to the offshore wind market. The 6-8MW turbines are not just an incremental evolution of the previous models and involve some changes to the design. For example, Siemens' 6MW turbine and the later 7MW model use direct drive (DD) technology that eliminates the need for a gearbox but requires a larger generator. Such turbines have fewer moving parts than traditional turbines with gearboxes but a more limited or no performance history.

The technical advisor's opinion on the technology used is important in understanding the extent of incremental technology risks compared with established technologies. The extent of modifications in the new models compared with the existing ones, the type and length of prototype tests and the ability of equipment suppliers to bring a new turbine model to market have also to be considered. Terms and conditions under the defect warranties and availability

Evaluating New Technologies:

- Informed by technical advisors' opinions
- Extent of modifications compared to previous models (completely new or evolution of existing technologies, extent of 'technology jumps')
- Equipment certification
- Extent of prototypes (onshore or offshore), number of prototypes and duration of prototype operations
- Track record of suppliers of bringing new technologies to commercial-scale production
- Technical warranties provided
- O&M support and risk sharing, particularly for unscheduled maintenance

[2] European Wind Energy Association (2015 report)

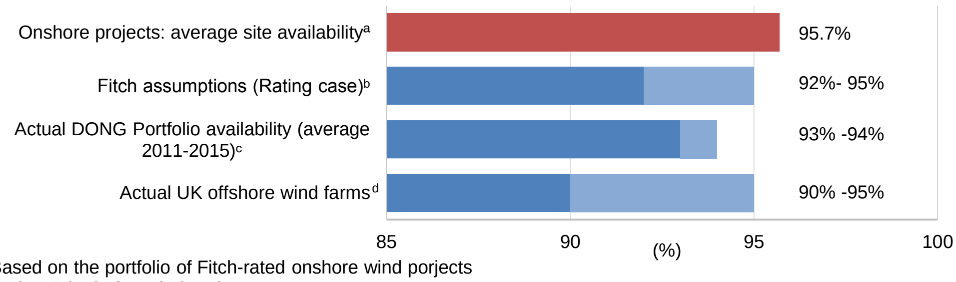
guarantees, as well as under the O&M agreements will be important considerations in assessing the extent to which the incremental technology risk is mitigated.

Project debt ratings are likely to be constrained to sub-investment grade in projects that employ technologies with no or limited track record, unless appropriate warranties and performance guarantees are provided by credible investment-grade manufacturers.

Availability Lower Than Onshore

Fitch expects offshore wind project availability to be lower than onshore, although still high. Across a portfolio of 19 Fitch-rated onshore wind projects, annual site availability averaged 95.7%, with 25% of annual observations showing availability of 97% and above. Based on the indications from the technical advisors and some actual operating data available, actual wind project availability offshore is lower by a few percentage points.

Figure 5
Overall Site Availability



[a] Based on the portfolio of Fitch-rated onshore wind porjects
[b] Rating Criteria for Wind Projects
[c] DONG 2015 Annual report
[d] The Crowne Estate - A Guide to UK Offshore Wind Operation and Maintenance (2013)
Source: Fitch

Turbine Availability May Be Guaranteed

Turbine manufacturers typically provide availability guarantees, which may be for the duration of defect warranty period or longer. If provided by creditworthy counterparties, Fitch will generally give full benefit to such guarantees and assume guaranteed availability levels in our rating case.

Turbine availability guarantees typically include several excusable events, such as expected service downtime, inability to access the turbines in case of adverse weather, force majeure events, and a certain grace period for the procurement of jack-up vessels in case major blade repairs are required. These excusable unavailability events should be separately estimated and accounted for in 'other losses' in the energy production forecast. In case they are not, Fitch may make an additional haircut to the guaranteed availability levels by a few percentage points to account for potential downtime that may not be covered under the availability guarantee.

The payout under availability guarantees is typically capped at a certain level (per year and/or over the whole agreement term). Fitch will verify that the cap is large enough to accommodate potential availability declines on an annual basis as well as on a cumulative basis.

Overall Availability Reduced by BoP Availability

The overall site availability of offshore wind projects is affected by BoP availability. BoP availability assumptions depend on the scope of the project and the redundancy in the key BoP equipment such as transformers and subsea cables. BoP redundancy is becoming more common in the sector, particularly as the projects are getting bigger, and is an important feature when assessing operating risk. For projects that include in their scope subsea transmission cables, cable redundancy is particularly important, so if there is an outage on one cable, the project can still export power via an altnerative cable. BoP availability is close to 100% in case of significant redundancy in normal operational years.

Weather Downtime

Wind projects are ultimately responsible for the weather risk in the operational phase, although O&M providers may take some of the risk. Risk allocation between the project and O&M provider is typically based on wave height thresholds for vessel access and on wind speed thresholds for helicopter access. Contractual provisions like this for accessibility in combination with the location of the site are differentiating factors among different projects. Production losses due to weather downtime included in the energy production forecasts have ranged from 0.5% a year to 2% in the projects we reviewed.

Cables Add to Operating Risk

Depending on the jurisdiction, subsea transmission cables may be excluded or included in the perimeter of offshore wind projects. In Germany, offshore wind operators are not responsible for the subsea cables during construction or during operations. The transmission grid operator owns the subsea cables and is required by law to perform cable repair works at its own cost and to pay compensation to the project at 90% of lost revenue in case of cable downtime. Such a set-up is favourable as it reduces the operating risk albeit it introduces interface risk with the grid operator.

In the UK, subsea cables are not part of the project in the operational phase as they are owned by independent regulated companies (OFTOs). In case of cable outage, wind projects are not compensated for lost revenues and can only rely on insurance proceeds. However, cable repairs are the responsibility of the OFTOs, without creating a burden on the wind projects. To ensure the alignment of interests, wind operators are often the O&M providers to the OFTOs to ensure some degree of control and gain some synergies.

In contrast, in the Netherlands the subsea cables are included in the scope of offshore wind projects. The financial impact of cable outages is potentially most severe as wind projects could be exposed to both lost revenues and costs of cable repairs, relying mostly on insurance compensation to recover these costs.

O&M Scope

The majority of offshore wind maintenance activities is associated with turbine maintenance. Scheduled maintenance typically involves major annual service in the summer months to minimise weather downtime. Unscheduled maintenance may vary from a simple inspection and restart, which might take a couple of hours, to the replacement of offshore substation transformers, which could take months to carry out.

Maintenance of the foundations, array and transmission cables and onshore facilities typically requires modest intervention and mostly inspection-based activities. Foundation maintenance may require some scour protection (e.g. rock dumping) and repair of boat landings. See Annex 1 for a summary of activities in the operations phase, the typical division of responsibilities and complexity of works.

Turbine suppliers like Siemens and Vestas play a key role in turbine O&M due to their expertise and equipment warranties, which are typically for five years. Depending on the chosen O&M strategy, turbine maintenance agreements may be for five years or for longer. If turbine maintenance agreements are only short term, project companies can renew the agreement, take the O&M turbine function in-house, or appoint an independent O&M provider. Some combination may also be possible with the project company choosing to take the O&M in-house but retaining some specialist support from the turbine manufacturer.

Turbine O&M arrangements based on long-term, fixed-price contracts that include scheduled and unscheduled maintenance are most protective for the project. Provision of vessels (main workboats and jack-up vessels) and helicopters, if relevant, under such agreements further reduces the risk of cost volatility.

Fitch understands that transition to self-operation is becoming more common, particularly in projects where project sponsors are experienced utilities and energy companies. In-house O&M may provide greater upside to project owners due to potentially lower costs, but may also results in greater operating risk. The agency will apply higher operating cost stresses under this set-up in our rating case projections.

Costs Significantly Higher Than Onshore

The proxy for operating costs (inclusive of O&M, administration, insurance) of EUR120,000 per MW is regarded as a reasonable long-term average, according to the information from technical advisors and the projects reviewed by Fitch. This is at least double the average operating costs we currently see in our onshore wind project portfolio. Higher costs offshore are mainly driven by the greater cost of turbine maintenance as well as vessel costs. Vessel costs can be significant, reaching about 25% of total, and vessel fuel costs may amplify the cost risk in case projects retain the responsibility for vessel provision. Cost budgets will vary depending on specific project characteristics, location, technical design and O&M arrangements.

Location Dictates Access Strategy

The distance from shore and the metocean (meteorological and oceanographic) conditions at the site will dictate the appropriate access strategy. The more remote locations have a higher exposure to weather risk. Fitch will look into how the transportation cost assumptions are factored in and sized in the financial projections, and how the risk of weather downtime and accessibility is mitigated from the contractual point of view.

Crew Transfer Vessels or Offshore-Based Strategy

Early offshore wind projects that are reasonably close to shore (20km-30km) have traditionally employed crew transfer vessels (CTVs) that make the trip from the onshore port to the site for every maintenance activity. CTVs can carry significant number of technicians, but response times and accessibility may be limited by transit time and sea conditions.

As projects are moving further offshore, O&M approaches are becoming more sophisticated. For sites that are far from shore (60km and over) with high winds and waves, projects are starting to employ new service offshore vessels (SOVs). These are larger and more robust vessels dedicated to a specific project. They will stay at the site, returning to shore every few weeks to rotate the crew and replace spare parts. Such offshore-based strategy should bring time savings and efficiencies as the trip from the onshore base may take three to six hours otherwise. The specifications of the offshore-based vessels may vary and some may provide direct access that allows safe crew and material transfers in wave heights up to two metres or above. Such vessels can also potentially store the spare parts, excluding major components.

Access Strategy

- Workboats (regular or offshore – based), contractual arrangements
- Jack-up vessels
- Helicopter

Figure 6

Access Strategies

	CTVs	SOVs	Helicopter
Accessibility	Up to 1.5m significant wave height Uses boat landing Daylight hours preference	Up to 2.5m wave height 24hr access Motion compensation gangway (for easier access from vessel to turbine)	Wave height independent Winch access Daylight hours restriction
Operational time (hours/year)	5,500	7,195	4,105
Number of technicians	12	45	6
Strengths	Most economic option Access to small ports	Good site accessibility 24/7 operations Less turbine downtime Spare parts on board	Good accessibility Fast transfer
Weaknesses	Non-productive travel time Daylight hours preference	More expensive than CTVs	Limited to daylight hours High costs

Source: Based on 'Wind Farm Service Vessels – Analysis of Supply and Demand' (2015), 4coofshore.com

Vessel Availability

The market for vessels to service offshore wind projects is developing and new models are being developed by marine contractors to make the vessels more robust and to allow safe transfer from vessel and turbine.

Securing a dedicated vessel for a specific project is beneficial, particularly if the responsibility to provide the vessel lies with a financially strong counterparty. Fitch understands that maintenance concepts based on SOVs mainly rely on this approach although there may be some SOV sharing among different projects. In these cases the sharing arrangements will be analyzed for time and responsibility allocation.

Helicopter Access Complementary and Becoming More Common

Turbine access by helicopter is complementary to the use of CTVs and SOVs and is becoming more common in project design. Helicopters are more expensive than boats but can transfer crew in weather conditions that prohibit vessel access and therefore are more suited to unscheduled maintenance when response time is critical. However, helicopters are restricted in terms of weight and size of parts which they can carry, and only minor repairs are possible. Poor visibility may also be an issue for helicopter access. Unless included in the scope of O&M agreement, project companies typically contract helicopters on a shared basis with other projects.

Jack-Up Vessels for Major Repairs

Bigger jack-up vessels are typically used during installation but are also required during operations in case of major component replacements such as turbine blades or transformers. Jack-up vessel deployment and mobilisation costs can form a significant portion of operating costs, making the repairs of a single turbine difficult to justify in isolation.

Jack-up vessels are typically not reserved for specific projects. Operators have to source them from the market as and when required, or based on the call-off agreements or vessel sharing agreements. This introduces some time uncertainty in case of major repairs.

Annex 1

Figure 7

Offshore Wind Projects' Typical O&M Activities

Type of work	Activities	Responsibility allocation	Complexity of works
Onshore logistics	Manage onshore site, leasing of quayside, parts storage and warehouse and office space. Bunkering and berthing services typically purchased from the port operators.	Project owner, in some cases turbine manufacturers.	Low
Offshore logistics	Provision of boats, helicopters, jack-up vessels, offshore accommodation (if relevant).	Owner or turbine manufacturer with some division of responsibilities for weather risk.	Medium to high
Turbine maintenance	Inspections, scheduled and unscheduled maintenance.	Owner or turbine manufacturer. Owners may work jointly with turbine manufacturers to cross-train. Post-warranty, owners may take over turbine maintenance, and manufacturers may remain contracted for more complex/unscheduled works. Potential sensitivities due to technical IP and know-how.	Medium to high
Turbine spare parts	Provision of turbine spare parts.	Turbine manufacturer. Limited spares market beyond manufacturers.	Low to medium
Array cable maintenance	Array cable surveys and repairs. Main issues related to movement/exposure or failure in extreme cases.	Owner. Array cables usually have five-year warranty. Survey and repair work may be sub-contracted to a specialist provider.	Low to medium
Foundation maintenance	Visual inspections, surveys, paintwork and cleaning marine growth, scour and structural surveys, foundation repairs (grouted joints, rock placements).	Owner. In contrast to turbines, foundations are not generally covered by warranties (reliance on insurance and certification). Works may be subcontracted to the foundation supplier or installer, or to specialist 3rd party provider.	Low to medium
Administration and operations	Administration, weather forecasting, SAP and marine coordination, SCADA, monitoring.	Owner.	Low to medium
Offshore substation	Non-intrusive inspections of topside switchgear and transformers. Infrequent intrusive services or repairs. Paint and secondary steelwork repairs.	Depends on regulatory set-up (owner, OFTO in the UK).	Low
Export cable and grid connection	Cable inspections (surface and ROVs), reburial campaigns, repairs of broken cables.	Depends on regulatory set-up (owner, OFTO in the UK).	Low to high
Onshore substations	Non-intrusive inspections.	Depends on regulatory set-up (owner, OFTO in the UK, grid operator).	Low

Source: Fitch based on the Crown Estate report 'A Guide to UK Offshore Wind Operations and Maintenance' (2013)