Scottish Enterprise

THE CROWN ESTATE





A Guide to UK Offshore Wind Operations and Maintenance

GL Garrad Hassan

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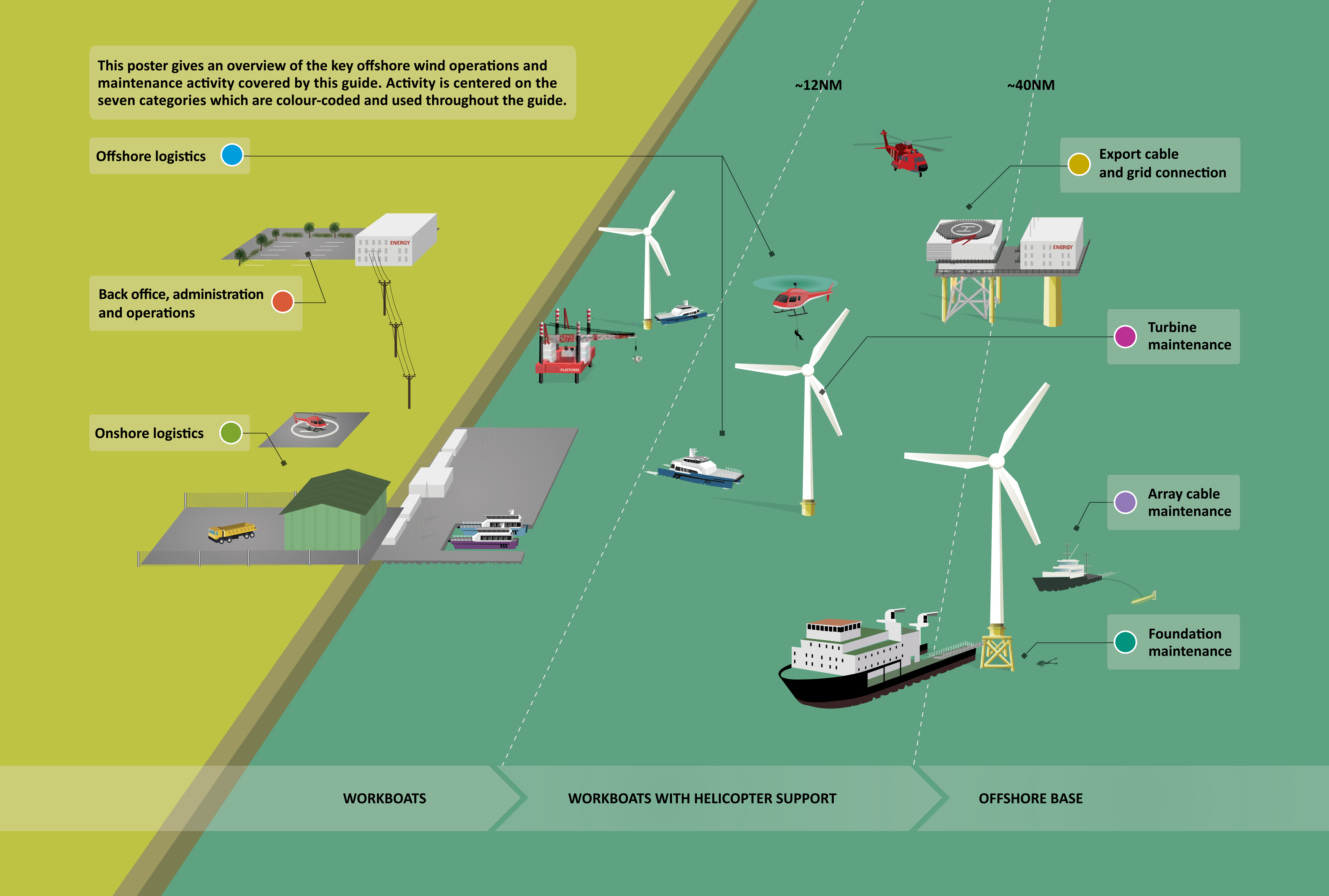
This poster gives an overview of the key offshore wind operations and maintenance activity covered by this guide. Activity is centered on the seven categories which are colour-coded and used throughout the guide.



Executive summary

The focus of the fledgling UK offshore wind industry has so far been the development and construction of wind farms in the unforgiving marine environment. But, as more and more offshore assets are commissioned and the number of operational wind turbines continues to grow, the technical and commercial challenges of operating projects is starting to receive much greater attention.

Offshore wind operations and maintenance (O&M) is a rapidly developing sector in its own right. Standardised technical and commercial practices have not yet emerged. Accepting that there are many paths offshore wind O&M can take, this 'Guide to UK Offshore Wind Operations and Maintenance' sets out the fundamental drivers that will shape the industry – and sheds light on the scale and nature of the opportunities it presents.

Further from shore

As more and larger offshore wind projects are built, further from shore, accessing the turbines to carry out maintenance will require new logistical solutions. As well as the relatively well understood workboat-based approach, increasing transit distances mean that strategies which include helicopter support and, eventually, offshore-based working will be needed.

The opportunity

O&M activity accounts for approximately one quarter of the life-time cost of an offshore wind farm. Over the next two decades, offshore wind O&M is going to become a significant industrial sector in its own right.

Based on the UK Government's projections for the deployment of offshore wind, the O&M of more than 5,500 offshore turbines could be worth almost £2bn per annum by 2025 – an industry similar in size to the UK passenger aircraft service business today.

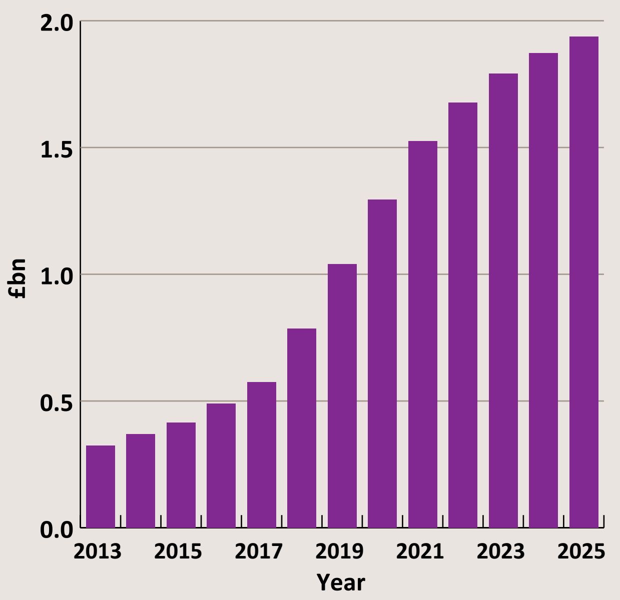
The players

The main customers for O&M services are the owners of the wind project, the supplier of the wind turbines and the owner of the electricity transmission connection. The precise contracting arrangements depend on several factors, not least the project owners' appetite for taking a "hands-on" role and the capabilities available in the third-party market. Many areas of offshore O&M will present opportunities for small and medium sized enterprises (SMEs) – particularly those where location, flexibility and new ideas are important.

All to play for

As this industry looks at the challenges ahead and strives for commercial maturity, it is those companies who actively engage now that will help to shape its future.

Figure 1.1: UK offshore wind O&M spend



Contents

1 Using this document

This guide has been designed to make it easy to find the information you need about offshore wind O&M.

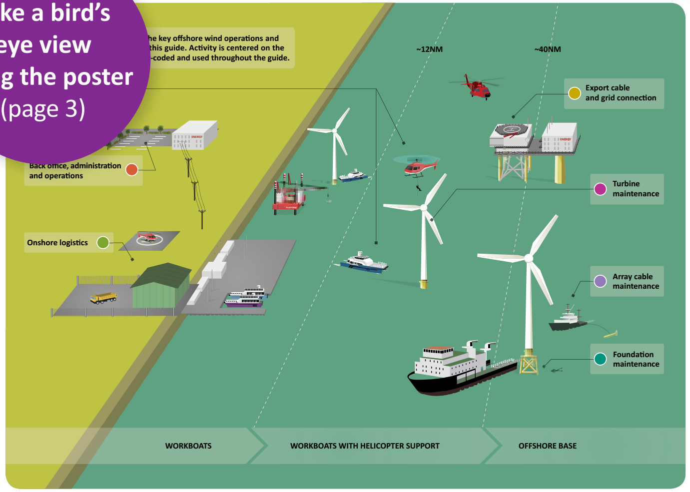
It will guide you through the important concepts followed by opportunities and players in this exciting and rapidly developing market.

As a reference document, the consistent colour scheme allows for quick access to detailed information about the areas of O&M activity relevant to you.

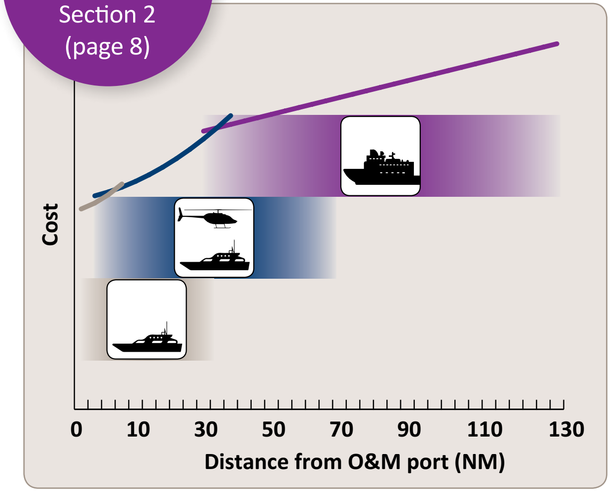
Colour scheme key:

- **Onshore logistics**
- **Offshore logistics**
- **Turbine maintenance**
- **Export cable and grid connection**
- **Array cable maintenance**
- **Foundation maintenance**
- **Back office, administration and operations**

Take a bird's eye view using the poster (page 3)

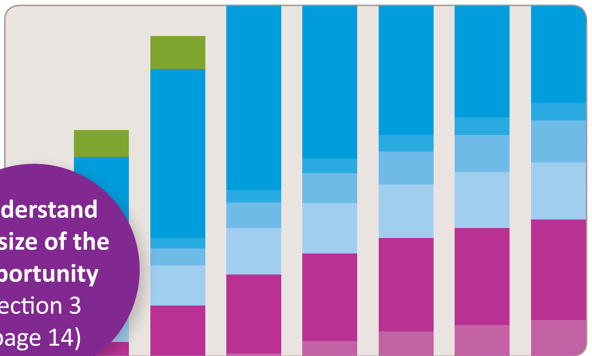


Get to grips with key concepts Section 2 (page 8)



Find out who's who in O&M Section 4 (page 18)

Information on the specific work packages Section 6 (page 32)



Understand the size of the opportunity Section 3 (page 14)

2 Introduction

Offshore wind O&M is the activity that follows commissioning to ensure the safe and economic running of the project. The objective of this activity is to make sure the project achieves the best balance between running cost and electricity output. O&M occurs throughout the life of the project, which is nominally 20 years. In this industry, O&M is broadly similar to inspection, repairs and maintenance (IRM) activity in the offshore oil and gas sector.

As implied in the name, O&M comprises two distinct streams of activity.

- ***Operations*** refers to activities contributing to the high level management of the asset such as remote monitoring, environmental monitoring, electricity sales, marketing, administration and other back office tasks. Operations represent a very small proportion of O&M expenditure, the vast majority of which is accounted for directly by the wind farm owner or the supplier of the wind turbines.
- ***Maintenance*** accounts for by far the largest portion of O&M effort, cost and risk. Maintenance activity is the up-keep and repair of the physical plant and systems. It can be divided into *preventative maintenance* and *corrective maintenance.*

    - ***Preventative maintenance*** includes proactive repair to, or replacement of, known wear components based on routine inspections or information from condition monitoring systems. It also includes routine surveys and inspections.
    - ***Corrective maintenance*** includes the reactive repair or replacement of failed or damaged components. It may also be performed batch-wise when serial defects or other problems that affect a large number of wind turbines need to be corrected. For planning purposes, the distinction is usually made between scheduled or proactive maintenance and unscheduled or reactive maintenance.

After the paramount safety of personnel, the second most important consideration when operating and maintaining an offshore wind project is the financial return. The objective of maximising the output of valuable electricity for sale – at least cost – can be thought of as driving all decisions by project owners about planning and carrying out O&M.

Key concepts

Offshore wind O&M involves a diverse range of activities. However, there are a few fundamental concepts that underpin the way that the key players are likely to approach O&M. Some of the most important factors in shaping O&M are:

- **Availability** – as a measure of the performance of the asset
- **Scheduled and unscheduled maintenance** – the nuts and bolts of keeping a project running smoothly
- **Access** – overcoming the constraints placed on operations by the weather and sea conditions
- **Cost reduction** – a continuing focus for the industry as a whole

These concepts are explained in the following sections.

Availability

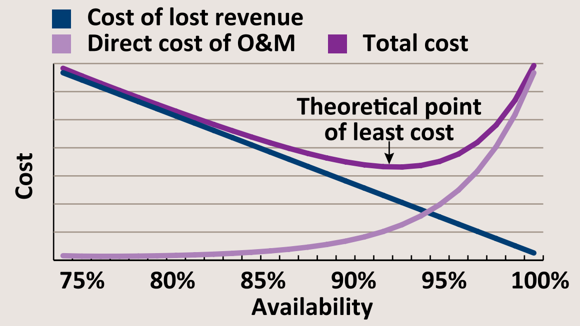
The economics of offshore wind O&M require a balance to be struck between the money spent on maintaining the project and the revenue lost when the electricity output is limited by technical problems.

An important measure of the performance of a project is known as availability. Availability is the proportion of the time that a turbine, or the wind farm as a whole, is technically capable of producing electricity. Availability is therefore a measure of how little electricity is lost due to equipment downtime. The balance between O&M cost and the lost revenue incurred by non-availability will be different for every project, but current offshore wind farms typically achieve availability of between 90% and 95%. Onshore wind farms, which face much lower O&M costs, typically achieve higher availability in the order of 97%.

Figure 2.1 shows indicative trends for the cost of O&M as a function of turbine availability. Although the cost of lost revenue declines towards zero as the turbines approach 100% availability, the cost of achieving it approaches exponential growth if 100% availability is required. If a wind farm owner invests too little in O&M, they will incur a penalty in the form of poor performance of the turbines and other components. Conversely, if an owner over-invests in O&M, with no regard to cost, they face diminishing returns as each increment in availability costs more than the last. The chart shows this theoretical optimum at the lowest point of the total cost curve, which of course will be slightly different for each project.

Availability is a technical metric and not directly related to the wind resource. For this reason it is important that it is not confused with capacity factor which, while also expressed as a percentage, is strongly a measure of the output of the project and, as such, is influenced by the average wind speed at the site.

Figure 2.1: Illustration of balance between cost and lost revenue



Access

One of the major hurdles to maintaining offshore wind projects is getting technicians on and off the turbines and offshore substations to carry out work. There are two major factors that influence the approach taken to gaining access:

- *Transit time* – the time needed to shuttle a service crew from the O&M base to the place of work. With limited shift hours available, the time taken to transport crews to and from a maintenance job cuts into the amount of time actually working to maintain the turbines and other plant. The further the project site is from the O&M base, the less time can be spent by crews on active work, given the longer transit time and risk of fatigue.
- *Accessibility* – the proportion of the time a turbine can be safely accessed from a particular vessel and is dependent on the sea conditions. For example if, at a particular project, the significant wave height[1] is greater than 2m for 40% of the time, a vessel that can transfer crew and equipment only in wave heights of 2m or less might be said to have 60% accessibility.

Both of these factors depend, to some extent, on the average sea conditions in a particular location – accessibility more so than transit time. Accessibility is especially critical for unscheduled maintenance since the project operator will often have no opportunity to plan any production outages for times of calmer sea conditions. When planning the approach to O&M for any given project, the owner will seek to reduce the total cost (direct cost and lost production) by seeking ways to reduce transit time and increase accessibility to the turbines.

Scheduled and unscheduled maintenance

Much of the maintenance activity is currently carried out on an ad-hoc, responsive basis when a wind turbine or other system fails. This is referred to as **unscheduled maintenance**. Such faults will require a range of different responses from a simple inspection and restart of a wind turbine, which might take a couple of hours, through to the replacement of an offshore substation transformer, which could take weeks or months to implement.

Other activities can be planned and executed in advance – **scheduled maintenance**. Typically, offshore wind turbines and associated plant have a defined scheduled maintenance regime which involves a major annual service supplemented by periodic inspection regimes. The annual services are usually conducted in the summer months to minimise weather downtime and lost production since average wind speeds tend to be lower in summer than in winter and may be carried out by a temporary, supplementary team of specialist staff and providers.

Cost reduction

Reducing the cost of the energy produced by offshore wind projects is a major focus for the offshore wind industry[2] and for the UK Government[3]. As a significant contributor to the overall cost of energy, finding ways to reduce the cost of O&M services and optimising asset performance have important roles to play.

As described under "availability" above, the incentives on the owner of the project to maximise the electricity production at least cost are very compelling and can be expected to drive improvements in all technical elements of O&M as the market gathers momentum. Particular technical developments expected to come forward include future wind turbine models with increased focus on:

- Improved remote monitoring and control to better understand the offshore plant and make previously unscheduled activities more predictable, reducing the logistical burden of putting technicians on turbines.
- Design and manufacturing improvements aimed at boosting reliability, thereby reducing the frequency and cost of unscheduled maintenance.
- Other, more fundamental, improvements such as the development of more reliable, gearless (direct drive) turbines.

Non-technical areas for cost reduction, although uncertain, may include greater synergies, sharing of resources such as jack-up vessels or other logistics plant between neighbouring projects and greater competition within the O&M supply chain for a range of contract packages.

'Perfect' O&M maximises availability, at least cost, by ensuring the best possible access to offshore plant, minimising unscheduled maintenance and carrying out scheduled maintenance as efficiently as possible – ultimately resulting in the lowest possible cost of energy.

[1] Significant wave height is a statistical measure of the typical height of sea waves and is used as an indicator of the severity of the sea state.
[2] The Crown Estate: Cost Reduction Pathways – http://www.thecrownestate.co.uk/media/305094/Offshore wind cost reduction pathways study.pdf
[3] DECC: Offshore Wind Cost Reduction Task Force Report – https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66776/5584-offshore-wind-cost-reduction-task-force-report.pdf

Offshore logistics

There is a wide range of conceivable equipment and techniques that can be used to ensure that technicians can access wind turbines and other project infrastructure, such as offshore substations. The main factors that influence the suitability of the offshore logistics solution include:

- Safety and regulatory factors;
- Response time (a function of speed);
- Flexibility;
- Personnel carrying capacity;
- Equipment payload;
- Weather and sea-state dependency; and
- Direct cost (of retaining and using a service).

Each offshore wind project has different characteristics which determine the optimal strategy for operating and maintaining the plant. The main factors are:

- Distance from onshore facilities;
- Average sea state;
- Number, size and reliability of turbines; and
- Offshore substation design.

Other than the number and reliability of wind turbines, probably the most influential factor on the cost of offshore wind O&M is the distance of the turbines from onshore facilities. For this reason, the distance from shore is also the primary consideration in determining the most cost effective approach to O&M.

Horns Rev 2 wind farm in Denmark features a fixed accommodation platform next to the substation.

Developers are in the process of installing wind farms at a rate that will see more than 5,000 operational offshore turbines in the UK by 2025. As sites further from shore are developed, in line with The Crown Estate leasing rounds, the average distance from shore-based O&M facilities will increase. This means that the 'typical' strategy employed to operate and maintain projects will gradually shift from strategies optimised for near-shore sites towards those that are more suited to very distant offshore wind sites.

Means of gaining access to offshore turbines currently being used include tried, tested and well understood workboats and the somewhat less well established helicopter services. Workboats are relatively inexpensive and can carry significant numbers of technicians, but response times and accessibility are limited by transit time and sea state. Helicopters, by comparison, are relatively expensive and cannot carry more than a few technicians and very little equipment but can respond quickly, have very short transit times and can operate without regard to the sea conditions (although poor visibility can impact accessibility).

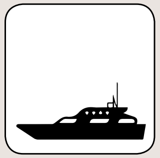
Although helicopters are a tried and tested element of offshore oil and gas logistics, they are a relative newcomer to UK offshore wind O&M and the safety and regulatory implications of their use has yet to be fully explored. While some operators are embracing helicopters (see case study 1) and the economic rationale seems strong for a significant number of sites, there is some uncertainty over how widespread their use may eventually be.

"The primary objective of offshore wind access logistics is to get people on and off turbines – as safely and as quickly as possible."

DR. NENAD KESERIC, STATOIL

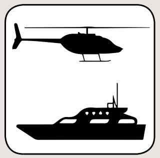
Workboats and helicopters can be thought of as complementary. The different characteristics mean that workboats may be more suited to scheduled activity when the turbine is not at risk of unexpected power outage. Helicopters, on the other hand, may be more suited to unscheduled activity when response time is critical to minimising down-time to maximise electricity production, depending on the cost of lost production weighed against the cost of using a helicopter.

Figure 2.2: Broad strategic approaches to offshore logistics



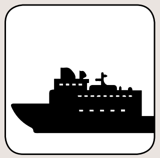
Workboat-based

Operating from a port base.



Heli-support

Workboats with support from helicopters.



Offshore-based

With fixed or floating offshore accommodation.

Although not currently seen in support of offshore wind O&M in the UK, transit distances required to access turbines at UK sites furthest from port will be so great as to require operations to be based offshore. Technicians therefore live at a base near or in the wind farm for a number of days (typically two weeks) and are transported to the individual turbines as appropriate. The base itself may be either fixed accommodation modules, similar to those used in the oil and gas sector, or boats of varying sizes such as 'motherships', offshore support vessels or jack ups.

In general, there are three main classes of offshore wind O&M strategy, as seen in Figure 2.2, with distance to port determining the most appropriate.

Based on the relative costs and characteristics of each of these approaches to offshore wind O&M, it is expected that workboat-based strategies are likely to be the most economic option for supporting near-shore sites, while shore-based workboats will benefit from support by helicopters (heli-support) for sites further from shore. The transit times for port-based workboats to the very furthest sites are so long that some form of offshore-based strategy is likely to become the only practical option for these cases.

For this guide, computational simulations have been conducted to establish the 'transition points' – the distance from port at which the lowest cost strategy changes from one strategic category to another. This work is based on consultation with industry, an understanding of the technical factors that influence O&M decisions and the outputs from an analytical tool that models total O&M cost (direct cost plus opportunity cost).

Figure 2.3: Illustration of lowest cost O&M strategy as a function of distance from O&M port

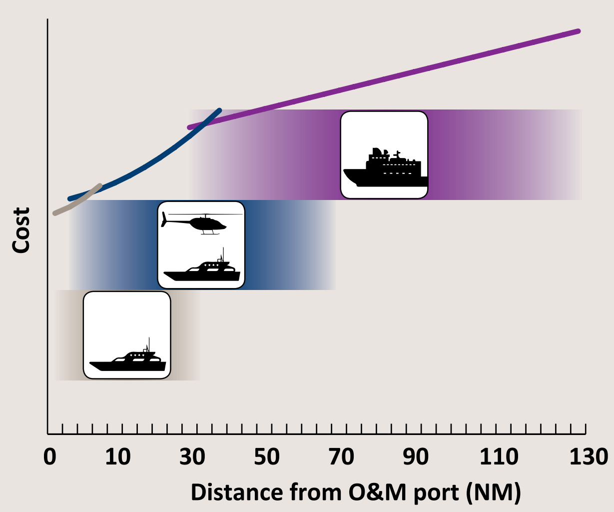


Figure 2.3 shows a simplified interpretation of the study's results for a generic offshore wind project at various distances from the nearest O&M port.

Figure 2.3 shows that 'transition points' emerge from the analysis at approximately 12 nautical miles (NM) (to include heli-support) and at 40NM (to offshore-based strategies). However, it is important to note that the very many site-specific factors such as sea conditions, regulations which affect aviation, safety considerations and suitability of available ports create uncertainty around these transition points. In some cases, the adopted operational strategy may not fall within these approximate guidelines.

CASE STUDY 1: Greater Gabbard – The UK's first helicopter support O&M strategy

Marine logistics

The Port of Lowestoft hosts the O&M facility that serves Scottish and Southern Energy (SSE) and RWE's 504MW Greater Gabbard Offshore Wind Farm. Marine operations are based on the use of four 18m, purpose built catamaran vessels on long-term charter from specialist workboat provider to the wind industry, Wind Cat.

Aviation support

Greater Gabbard is notable as the first UK offshore wind farm to routinely deploy helicopters in support of marine operations as part of the O&M strategy. A contract with offshore aviation firm, Bond Air Services, has seen a staff of five providing improved turbine access seven days a week using a Eurocopter EC135 helicopter to hoist technicians onto specially designed turbines since September 2012. Helicopter access is seen by the owners as an important means of reducing the frequency and duration of periods when turbines cannot be accessed due to weather conditions, especially in winter. The rapid transit capability afforded by helicopter support is of particular benefit to Greater Gabbard since, while relatively close to shore (20NM), it is 40NM from the support base at Lowestoft.

CASE STUDY 2: Sheringham Shoal – Purpose built port infrastructure

Sheringham Shoal Offshore Wind Farm, off the coast of Norfolk, comprises 88 Siemens 3.6MW turbines and entered operation in September 2012. The owners, Scira (a joint venture between Norwegian companies Statkraft and Statoil), have selected Wells-next-the-Sea for the operations base and have signed a 50 year lease.

Proximity

The main advantage of Wells is the proximity to the project, just 20NM – something which has been the overriding factor in preference to other ports with more pre-developed facilities. To serve the workboats, a new outer harbour has been constructed (see image) fitted with pontoons. There is an ongoing dredging programme to maintain the channel depth at one metre at low tide to maximise vessel operational windows.

The base

The operations base, comprising administration and associated storage facility, is about 3KM south of Wells. Each day the technicians are transported to the outer harbour by minibus to minimise the disturbance to the town from travelling in separate cars. The operations base will serve around 60 permanent employees. Base staff includes a small management team of 13, three on secondment from Norway and the rest recruited locally.

Onshore logistics

Shore-side services are vital to support offshore logistics and all offshore wind farm O&M activity needs access to port facilities such as load-out and workboat mooring. As set out in the previous section, the primary consideration is the distance between the project site and the dedicated port facilities. This is especially true for projects employing workboat-based or heli-support access strategies for which the cost increases very rapidly with transit distance. For some projects, this driver is proving powerful enough to take preference over the specification of existing facilities – leading to the creation of new infrastructure as close to the project as possible (see case study 2).

Multiple ports

While day-to-day personnel and light equipment transfers benefit greatly from short transit times, wind turbine overhauls or planned major component replacement are less distance sensitive but require more substantial load-out and crane capacity. Conceivably, this could result in multi-port strategies with specific activities focused on different locations with the most appropriate facilities. In international sea-regions such as the North Sea, it is possible that sea transport of components can take place between any of the bordering countries and a wind project. For this reason, the location of the component supply chain factories is a significant factor in determining which port is used for these operations.

Future trends

As the average distance to shore of the operational fleet of wind turbines increases and offshore-based access logistics begin to emerge, O&M costs will become less sensitive to distance from shore (primarily because access to offshore bases or motherships will require return to port far less often – see Figure 2.3). This relative insensitivity to distance may mean that more distant but better equipped ports become optimal.

3 The opportunity

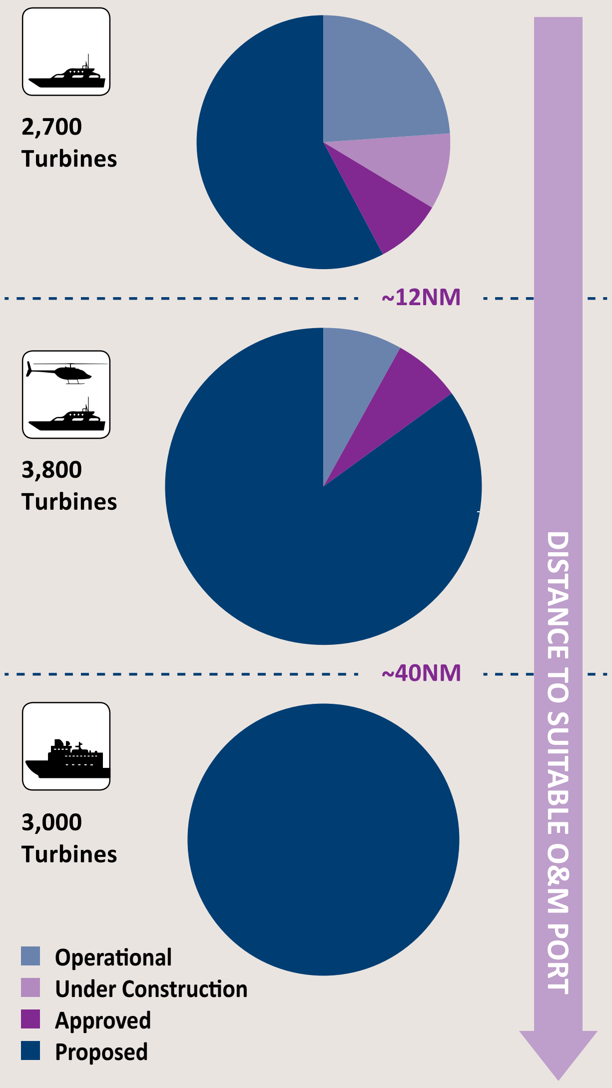
The UK currently has the most ambitious programme for offshore wind installation in the world. O&M activity accounts for approximately one quarter of the life-time cost of an offshore wind farm. Over the next two decades, offshore wind O&M is going to become a significant industrial sector in its own right.

Figure 3.1 provides a current status of UK offshore wind projects[4] by distance to port:

i. closer to shore than 12NM, where workboat-based strategies are most likely to be cost optimal;
ii. between 12NM and 40NM from shore, where heli-support strategies are most likely to be cost optimal; and,
iii. more than 40NM from shore, where offshore-based strategies are likely to be the most practical and economic approach to O&M.

It can be seen that a similar number of turbines fall into each of the three categories of O&M strategy. It should also be noted that the development status of the projects significantly reduces as the projects' distance from port increases – no projects further than 40NM from port have yet progressed past the planning consent milestone. As the UK offshore wind sector matures, the workboat-based O&M strategies seen until now will be joined by increasing numbers of turbines being serviced under heli-support and eventually offshore-based strategies.

Figure 3.1: Total projected turbine numbers by distance to shore



The Crown Estate leasing of sites for offshore wind projects

The Crown Estate has promoted the development of wind energy programmes on its offshore marine estate by undertaking a number of leasing rounds for offshore wind deployment, usually referred to as Rounds.

Round 1 (2000) was to cater for demonstration scale projects of up to 30 turbines with the selection of sites largely driven by developers and resulted in eighteen sites being awarded.

The **Round 2** tender process (2003) was for commercial scale projects within three strategic areas (the Greater Wash, the Thames Estuary and Liverpool Bay). Fifteen successful projects were awarded Crown Estate agreements for lease and included sites within and beyond territorial waters.

In 2008, The Crown Estate decided to invest in a further programme to enable the delivery of the Government's plan for offshore wind generation capacity by 2020, known as **Round 3**. This further programme is intended to provide 25GW of offshore wind energy**.** The Round 3 zones are nine large areas of development within which individual wind farm sites are being progressed. Individual developers or consortia have been awarded exclusivity to develop projects in each zone.

Also in 2008, a process for leasing wind farm sites in **Scottish Territorial Waters** was undertaken and a number of development companies were awarded exclusivity agreements to take forward development.

In 2009 the developers were offered an opportunity to **extend Round 1 and Round 2 projects.** The aim of this leasing round was to offer more capacity to the market and to ensure an unbroken supply / build trajectory.

[4] These data refer to all projects currently being developed in UK waters and do not refer to a particular date. The final number of turbines delivered at a particular date is likely to differ

The transition towards offshore-based O&M strategies mirrors the site allocations determined by The Crown Estate's leasing round programme described on the previous page. The Round 1 sites are relatively small, close to shore and suited to a workboat-based O&M strategy. Round 2 sites are larger and further from shore and, while workboat-based strategies have been the main approach to O&M, at least one operational project (Greater Gabbard) is relying on helicopter support – while several projects' O&M strategy is yet to be finalised. Scottish Territorial Waters projects are likely to see a mix of strategies, potentially including all three options whereas Round 3 represents a step change in both size and distance from shore and has driven much of the consideration of offshore based strategies. Figure 3.3 summarises the UK O&M spend by strategy class. For more detail on timings see Figure 3.4.

The value chain

As introduced in the poster on page 3 of this guide, the value chain for offshore wind O&M can be categorised into seven areas of activity:

- **Onshore logistics**
- **Offshore logistics**
- **Turbine maintenance**
- **Export cable and grid connection**
- **Array cable maintenance**
- **Foundation maintenance**
- **Back office, administration and operations**

This colour coding of O&M activities is also used as a key to Figures 3.2 and 3.4. A more detailed description of these categories is provided in Table 3.1 and in the contract packages in Section 4 and 6.

Table 3.1: Categories of offshore wind O&M activity[5]

Supporting Operations

Onshore logistics – port-side activity, warehousing and on-site office space

Offshore logistics – equipment, planning and resources required to move people and equipment at sea including work boats, offshore bases, helicopter services and jack-up services

Back office, administration and operations – performance monitoring, electricity sales etc.

Equipment Maintenance

Turbine maintenance – the technicians and equipment needed to inspect and repair the wind turbines

Export cable and grid connection – the technicians and equipment needed to inspect and repair the connection of the offshore power plant to the onshore power transmission system, including onshore and offshore electrical substations and export cables

Array cable maintenance – the technicians and equipment needed to inspect and repair the susbsea cables that connect the turbines to create a unified power plant

Foundation maintenance – the technicians and equipment needed to inspect and repair the turbine foundations and sub-sea structures

[5] Not included in these categories are other operational expenses incurred by wind farms such as insurance and offshore site leases

Figure 3.2: O&M cost per turbine for 3 classes of O&M strategy broken down by function

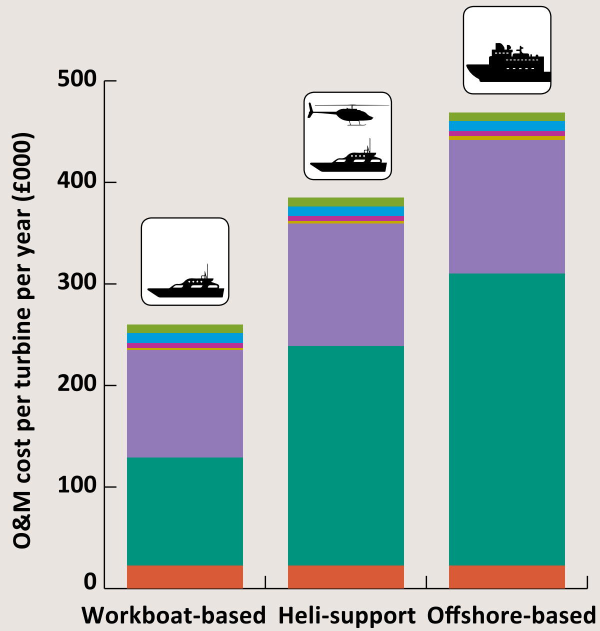


Figure 3.3: UK O&M spend by strategy class

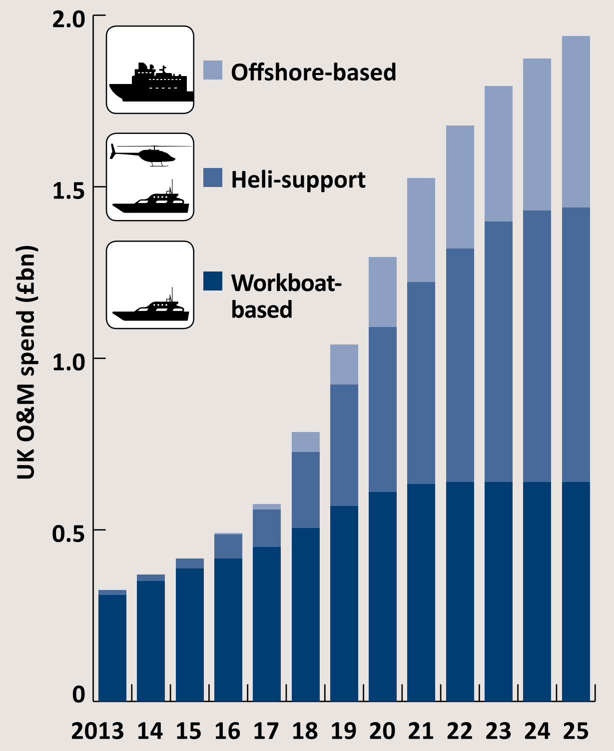
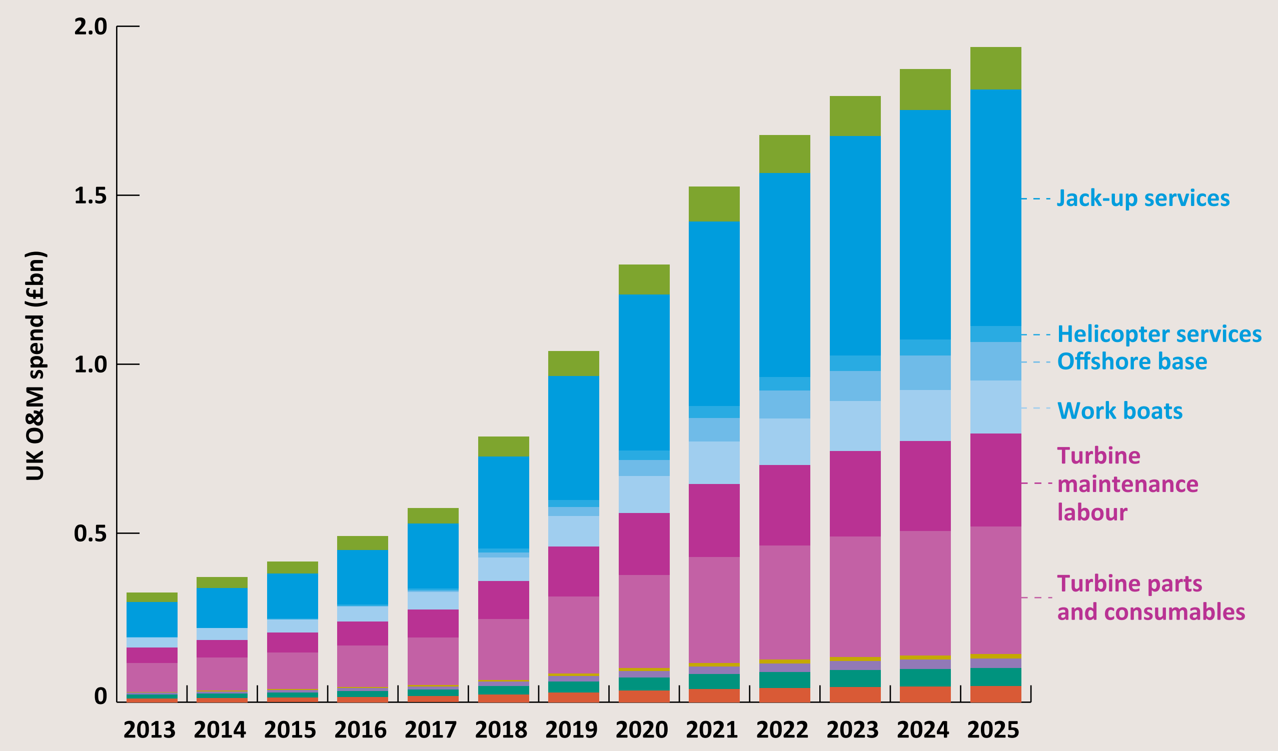


Figure 3.4: UK O&M spend by category



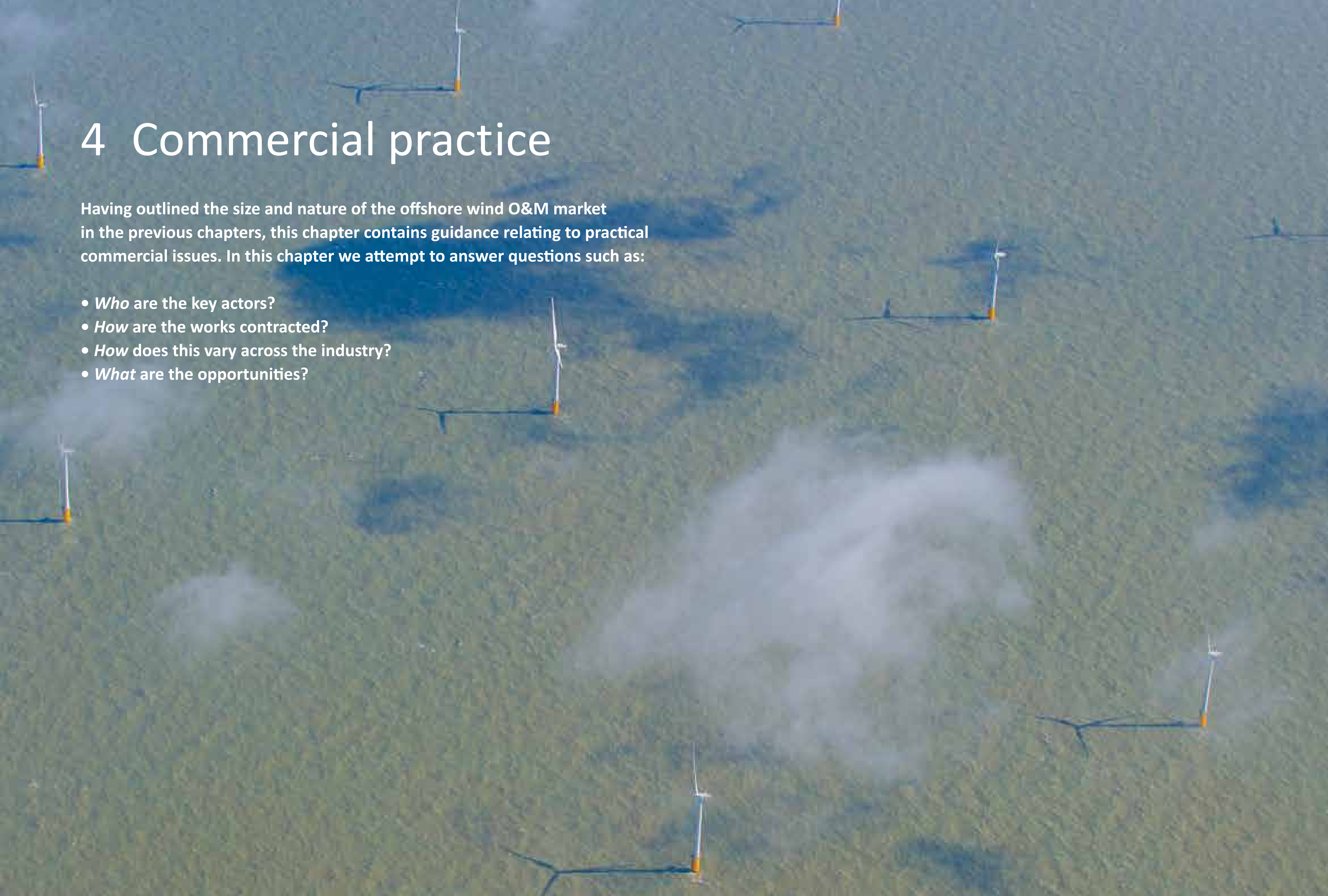
The cost of maintenance activity is best considered on a per turbine basis as costs tend to scale most strongly with turbine numbers, rather than per MW of installed capacity. An estimate of the cost per turbine per year of each of the classes of strategy varies as shown in Figure 3.2. Although O&M costs per turbine for wind farms further from port are markedly higher than for sites closer to shore, the average turbine size can also be expected to be larger, meaning that any increase in the per MW O&M cost will not be as pronounced as suggested by Figure 3.2.

Market size

The primary driver of increased O&M activity is the number of operational turbines. Analysis based on UK Government projections for offshore wind shows that the number of installed turbines will increase to more than 5,500 by 2025 with O&M spend in the categories identified increasing to almost £2bn per year. By 2020 there could be as many as 50 offshore electrical substations supplying offshore wind energy to the power grid.

The breakdown of the cost of O&M activity in Figure 3.4 gives a projection of the scale of the market for each of the seven major groups of activity identified in Table 3.1, with turbine maintenance and offshore logistics further broken down into more detailed categories.

Based on analysis of the distance from shore of each wind farm and the most likely O&M strategy, it is also possible to project expenditure on O&M across the three classes of strategy.



4 Commercial practice

Having outlined the size and nature of the offshore wind O&M market in the previous chapters, this chapter contains guidance relating to practical commercial issues. In this chapter we attempt to answer questions such as:

- ***Who* are the key actors?**
- ***How* are the works contracted?**
- ***How* does this vary across the industry?**
- ***What* are the opportunities?**

Who's who – the key actors

O&M provision is driven by three key groups: the project owner, the wind turbine original equipment manufacturer (OEM) and the offshore transmission owner (OFTO).

- The **project owner** will procure all operational services associated with the offshore wind project itself up to the point of interface with the OFTO usually on the offshore substation(s). They will typically drive the selection of the operational strategy and may choose to contract the majority of services through the wind turbine OEM or otherwise take a more "hands-on" approach by procuring a wider range of services directly, as explored further below. This group can be broken down into four further categories:
  - **Large, vertically integrated utilities**, namely the UK "big 6"[6] plus other European utilities, notably DONG, Vattenfall, Statkraft, EDPR, Eneco and Stadtwerke Muenchen.
  - **Oil & Gas companies**, such as Statoil and Repsol.
  - **Supply chain players** taking an active equity stake in projects through to construction, such as Siemens and Fluor.
  - **Specialist developers**, such as Mainstream Renewable Power, who may sell their stake prior to construction but will play an important role in driving O&M concept selection.
- For the first years of operation at least, the **wind turbine OEM** will be responsible for maintenance of the wind turbines themselves, in association with the main equipment warranties. Depending on the contracting approach of the project owner, the wind turbine OEM may be responsible for offshore logistics as well as onshore infrastructure. The leading wind turbine OEMs in the UK market are currently Siemens, Vestas and REpower. Leading new entrants targeting the UK market include: AREVA, Alstom, Gamesa, Mitsubishi and Samsung.
- The offshore transmission infrastructure is owned and operated by the **OFTO**, who in turn will let one or more maintenance contracts for these assets. In some cases, the wind farm project owner itself has bid for and won such maintenance contracts in an effort to secure some degree of control over the risks associated with these extremely important export assets and as a means of making the O&M regime for the generation and transmission assets together, more efficient. The leading OFTOs are Transmission Capital Partners, Blue Transmission and Balfour Beatty.

All offshore wind projects today are managed using a multi-contract approach with overall responsibility resting on the project owner. The split of contracts between parties will depend on the overall strategy chosen by the owner and the length and scope of the turbine warranty.

[6] The so-called "big six" are generation plant developer/owners with electricity supply businesses, which account for the vast majority of electricity retail in the UK. They are: Centrica, EDF, E.ON, RWE, Scottish Power and Scottish and Southern Energy (SSE)

The importance of warranties

The wind turbine OEMs continue to dominate offshore wind O&M activity. The primary reason for this is related to the equipment warranties which are sold, as standard, alongside the capital plant. With a typical duration of five years, OEMs guarantee minimum levels of availability on the condition that they have responsibility for day-to-day maintenance activity. This alignment of risk and responsibility allows for it to be commercially possible for the OEMs to offer such a warranty over the equipment in service. To date, many OEM warranties have guaranteed a certain level of availability of plant without regard to production from the wind resource. More recently there has been a move to link availability-based contracts with production targets.

It may be argued that the unparalleled level of knowledge that the OEMs have about their wind turbine products represents another compelling reason for their selection as the primary contractor during operations.

When the main warranties expire, the project owner is presented with three options:

1. Renew the O&M agreement with the incumbent wind turbine OEM; or,
2. Take the O&M function in-house; or,
3. Award a contract for O&M provision to an independent provider.

Some combination of the above options is also possible. For example, the project owner may choose to take the O&M function in-house but retain some specialist support from the OEM. In fact, this exact hybrid approach has been adopted by at least one UK Round 1 offshore wind project as explored in case study 3.

Wind turbine warranties represent a significant barrier to entry for potential independent O&M providers and, even following their expiry, the specialist know-how and intellectual property held by the OEM represents a substantial challenge for such companies. However, there is some evidence of a potential market for such providers emerging – such as SeaEnergy Marine, who are pioneering an offshore based service offering.

CASE STUDY 3: Scroby Sands – life after the warranties expire

Scroby Sands, built by E.ON in 2004 with 30 Vestas V80 turbines, was one of the first offshore wind farms to be built and for the first five years of operation, the O&M activity was largely managed under the terms of the warranty agreement with Vestas.

As this warranty approached expiry, E.ON reviewed its options and decided to take much of the O&M activity in-house. This required a significant up-skilling of staff and a steep learning curve as E.ON sought to move to a much more proactive strategy, investing in a new service vessel and managing logistics. E.ON also tendered for a maintenance contract and, after receiving a number of bids, chose Vestas. In addition, Vestas was retained on a technical support agreement covering software upgrades, design changes and major repairs.

In 2013, the Vestas contract will expire and E.ON has decided to take on all of the maintenance activities internally, with all technical staff, including the technicians E.ON employs. This will complete the transition from a hands-off owner to a fully hands-on owner.

"If you're proactive and you detect a bearing failing, you may be able to shut that turbine down for two days, change that bearing and it has cost you a few thousand pounds. If you fail to pick up the bearing failing, drive it to destruction and destroy the gearbox, the costs can be enormous. You could be waiting 12-14 weeks for a jack-up barge at tens of thousands of pounds a day."

JON BERESFORD, OPERATIONS MANAGER SCROBY SANDS, E.ON

"Hands-on" and "hands-off" project owners

As indicated above, project owners are taking a range of different approaches to contracting O&M services both during the warranty period and beyond. This is best thought of as a spectrum from those wishing to adopt a "hands-on" approach – taking direct responsibility for a wider range of activities – and those who prefer to take a "hands-off" approach – relying on a few key contractors to look after the project. This is driven primarily by the strategic interests and corporate policy of the owner – essentially, where they see themselves adding value.

Historically, the "hands-off" approach has been more prevalent. This was a natural continuation of practice from the onshore wind business at the time. However, we have seen an increasing shift towards many owners taking a more proactive approach to O&M, not only following the warranty period, but in many cases from day one, as explored in case study 4.

Table 4.1 explores some of the key differences between the "hands-on" and hands-off", as well as middle ground compromise.

Table 4.1: Indicative risk and responsibility allocations

Risk/Responsibility	Hands-off	Hybrid	Hands-on
Access (weather) risk	OEM	OEM/Owner	Owner
Transport & logistics	OEM	OEM/Owner	Owner
O&M contract term	10-15 years	5 years	2 years
Owners staff on-site	Inspection only	Day-to-day supervision/ Joint working with OEM	Joint working with OEM
O&M in-house post-warranty	No	Maybe	Yes

CASE STUDY 4: DONG Energy – the epitome of a hands-on owner

Danish energy company DONG has been building and operating wind farms for more than 20 years. To date, its approach to offshore O&M is notably 'hands-on' with DONG owning and operating marine assets such as boats and providing technicians and other personnel to work under the management of wind turbine manufacturers in the maintenance of offshore turbines.

Mother of invention

The principal driver of DONG's approach to contracting O&M services is the fact that, as a first-mover in the offshore wind business, it was necessary to develop in-house capabilities for which specialist suppliers with adequate experience and resources had yet to emerge.

Down-time risk

In addition to the lack of qualified suppliers during the early days of offshore wind, there is also a contractual element to the decision to bring a large proportion of O&M in-house. As the ultimate supplier of electricity, the wind farm owner is exposed to the risk of lost revenue due to down-time of turbines or other plant. Contractual arrangements which efficiently pass this risk to another party are difficult to establish.

"One advantage of turbine technicians working directly for the wind farm owner is that they are able to take a long-term view on the project – well beyond the initial five year warranty period."

MICHAEL SIMMELSGAARD – HEAD OF GLOBAL OPERATIONS, DONG ENERGY

CASE STUDY 5: MCS – flexibility unlocks access to European markets

Largs-based maritime company Maritime Craft Services (Clyde) Ltd (MCS) is expanding its operations in Europe, with the purchase of five new vessels worth around £15 million. The three boats will be used to service MCS's offshore energy operations in Germany and Denmark, as well as at home and are expected to create 50 new jobs and generate up to £5.5 million turnover per year.

"We are very excited about this new development, which should further our presence within the German Offshore Renewable market. We are now able to service the offshore renewable industry with these state of the art crew transfer vessels which are operated by our highly experienced and certified crew."

DIRK KUIJT – MANAGING DIRECTOR, MCS

There is interest from the market in a wide range of warranty lengths from two years to the full life-time of the asset (approx. 20 years). This mirrors ongoing consideration and maturation of thinking in this area and is likely to result in a range of approaches across the spectrum presented above, reflecting the range of project owners currently operating in the industry as well as the appetite of incumbent and new entrant wind turbine OEMs. Trends from the onshore wind business over the last 5 years indicate that many OEMs are actively pursuing a much larger revenue stream from O&M as sales of new plant in many global national markets slows. There is some evidence that this logic is being extended to offshore wind as indicated by the increasing market availability of longer and, in some cases, stronger warranties.

For consortia and for financial investors, a "hands-off" approach is likely to provide a more acceptable risk profile given the lack of in-house capabilities or the complications of corporate governance. Leading utilities and energy companies with a long-term strategic interest in the technology are likely to sit towards the "hands-on" end of the scale.

The range of approaches in play is a symptom of a relatively immature industry. Because of this, companies considering entering this space are advised to adopt a flexible attitude to contracting. A particular service may be offered to the owner for project A and to the wind turbine OEM for project B. Flexibility and solid market intelligence on the contracting approach are likely to be critical success factors.

Opportunities for SMEs

Whilst the major commercial and operational decisions for the running of an offshore wind project are driven by the key actors, mainly comprising large companies, there are significant opportunities within the value chain for Small and Medium Enterprises (SMEs). This is particularly the case where one or more of the following factors are in play.

- **Location:** Some services are best provided by local companies who are already serving offshore industries, especially where proximity to the project is crucial. These providers will offer established local infrastructure, skills and knowledge to deliver the required services competitively, when compared to competition from elsewhere. For example, a company with an established fleet of workboats with a track record within a given region will be well placed to win offshore logistics contracts for projects locally when compared to a larger foreign competitor. Port related services are of relevance here, given how important proximity to the site is as an economic driver. However, as case study 2 illustrates, infrastructure upgrades may be required to make the closest port suitable for the required operations.
- **Flexibility:** SMEs are often better placed than larger

companies to provide a flexible solution to their clients to take account of project-specific factors and therefore offer better value. This applies to both technical and commercial aspects. For example, an SME which is prepared to offer Remotely Operated Vehicle (ROV) services to a project owner, a foundation contractor and an OFTO on the same project but with different scopes of work may have a significant advantage over a larger provider which may have less technical and commercial flexibility. The example of Maritime Craft Services also shows how commercial and technical flexibility can also allow SMEs to break into overseas markets in this sector (see case study 5).

- **Specialism and innovation:** SMEs with bright ideas and the entrepreneurial expertise to commercialise them can be successful in this market. Looking to the future, there are challenges facing O&M where innovative solutions or specialist providers are required, including:
  – ***Marine logistics:*** solutions and providers which reduce direct costs, increase access or mitigate Health, Safety and Environmental (HS&E) risks are likely to be successful, as demonstrated in the cases of MaXccess and Coastal Marine Boatbuilders (CMBL) (see case studies 6 and 7). Examples of this include novel access systems, enhanced marine co-ordination software, personnel tracking systems and next generation workboats.
  – ***Training:*** the industry lacks consistent, standardised training requirements for the range of roles required. These will inevitably emerge and therefore an opportunity exists for providers to help shape this process now and benefit from the outcome in the years ahead. This is particularly for the case of re-skilling personnel who are changing sectors, as illustrated by the example of 3sun (see case study 8).
  – ***Subsea inspections:*** The requirements for environmental and technical inspection of the subsea elements of wind projects are an already significant aspect of O&M provision. This is only likely to increase as projects are constructed in new environments and conditions. Diver operations are common and this in itself increases HS&E exposure. Providers who can bring economic solutions to the market that reduce the requirement for divers, but deliver the required data and results are likely to be successful. Specialist provider Briggs Marine are an example of an SME that has broken into this space, providing a flexible, tailored approach to client needs (see case study 9).
  – ***Reducing the need for maintenance:*** There is an increased focus on design for reliability and maintenance in the industry in general, but the reality is that there is a still a long way to go. Wind turbine, foundation and electrical elements of the project infrastructure would all benefit from innovative solutions which can demonstrably reduce O&M spending and downtime. Remote surveillance in wind turbine nacelles to allow improved remote diagnostics is an example of this.

CASE STUDY 6: MaXccess – accessing the O&M market through innovation

Designed and built in the UK, MaXccess is the only commercial access system in use today. It creates a secure and measured connection by gripping one of the boat landing buffer tubes. This prevents hazardous vertical and horizontal bow motion while allowing the vessel to roll, pitch and yaw freely. It increases significant wave height working conditions from 1.5m to more than 2m.

The system was developed by a rapidly emerging company in the North East of England that has experience of providing marine engineering solutions. With access a major challenge for the offshore wind industry, OSBIT Power developed an ingenious design from scratch which was successfully wave tank trialled. This led to interest from Siemens and Statoil who tested the prototype unit on the floating Hywind demonstration turbine. This success has led to commercial orders from Siemens and Statoil. The unit has been operational on Greater Gabbard wind farm since August 2012 and at Sheringham Shoal since January 2013.

"It is all about developing niche technologies where we can lead the world…elegant technology to save cost and increase safety."

DR TONY TRAP – MANAGING DIRECTOR, OSBIT POWER

CASE STUDY 7: CMBL – delivering the next generation of workboats

As offshore wind farms move further out to sea, demands made on support vessels are changing significantly. Essex-based CTruk Boats has had its sights set on this development for some time and recently initiated the build of a 50t payload support vessel, designed to meet the tougher requirements of the next phase. This is the first complete vessel build to be contracted out by CTruk and the selection of Coastal Marine Boatbuilders (CMBL) in Eyemouth in the Scottish Borders represents a strategic partnership for potential future growth. The venture represents a departure from CMBL's traditional business and the Eyemouth yard now plans to construct a specialist production facility for larger commercial vessels.

CASE STUDY 8: 3sun – move into offshore wind delivers record revenue growth

Strong demand for turbine installation technicians and O&M engineers saw 3sun record 92.3% revenue growth last year.

The company is currently raising headcount further, from 220 to 300, with former Armed Services personnel often featuring amongst new recruits. With so many new technicians coming on board, 3sun has been struggling to secure sufficient training places. This prompted 3sun to buy a training provider late last year. "Training is a major part of our spend. This year, we will probably spend half a million pounds on training," said Managing Director, Graham Hacon.

In addition to supplying construction staff, 3sun has also secured two three-year offshore wind O&M contracts. It was recently awarded a statutory inspection and general engineering contract by Scira, the operator of Sheringham Shoal offshore wind farm. The 317MW development is close to 3sun's headquarters in Great Yarmouth, Norfolk. The company is eyeing the crew transfer vessel market. Rather than simply supplying boats, 3sun envisage offering clients a turnkey solution, comprising both vessels and technicians.

"Training is a major part of our spend. This year, we will probably spend half a million pounds on training."

GRAHAM HACON – MANAGING DIRECTOR, 3sun

CASE STUDY 9: The Briggs Group – repair and maintenance of offshore cables

© The Briggs Group

The Briggs Group has secured a five year agreement extension with SSE (Scottish and Southern Energy). The deal will see Burntisland-based Briggs deploying tailored systems from among its fleet of 40 vessels to repair and maintain a network of over 500 kilometres of cable in some of the harshest marine environments in Europe.

Under the five-year agreement Briggs will provide 24/7 immediate mobilisation and specialised end-to-end support for the maintenance of the SSE network comprising 102 live cables totalling 515km supplying islands, homes and businesses across the region. This will include network survey, cable protection work, cable installation, repair and testing through all seasons in challenging locations where currents can reach speeds in excess of eight knots.

With over 40 years experience in the marine sector, Briggs aims to become a leading provider to the renewables market with the launch of their integrated maintenance solution for windfarms.

"The offshore renewables industry is set to play a crucial role in providing sustainable and secure energy to the United Kingdom, our objective is to become a major provider to generator, transmission and export supply chains."

CRAIG ENGLISH – OPERATIONS DIRECTOR FOR SALVAGE AND SUBSEA CABLES, BRIGGS MARINE

Contract packages

Figure 4.1 illustrates potential contract packages (outer ring) which are let by the key actors (inner ring). Underpinning everything is Health, Safety and Environment (HS&E) and Training considerations, as highlighted in green. The colours of the outer ring correspond to the seven categories of O&M activity introduced in the poster on the inside cover of this guide and further detailed in chapter 6 as outline work packages. These packages should be considered as a representative guide and will vary quite considerably from project to project. The term "tier" is deliberately omitted given the ambiguity of its meaning and the lack of a standard contracting hierarchy within the offshore wind band. In order to highlight potential opportunities for SMEs, a red band has been added outside those packages where the greatest opportunities for SMEs exist.

Colour scheme key:

- **Onshore logistics**
- **Offshore logistics**
- **Turbine maintenance**
- **Export cable and grid connection**
- **Array cable maintenance**
- **Foundation maintenance**
- **Back office, administration and operations**
- **Greatest SME opportunities**

Figure 4.1: Contract packages against key actors

Building on Figure 4.1, the following coloured sections describe some of the key commercial aspects against each of the seven categories of O&M activity. More detail on each of the contract packages identified in the outer ring is provided in Section 6.

Onshore logistics

The owner will also tend to manage the onshore site, sub-leasing or providing for free certain areas to the wind turbine OEM. Facilities will include the leasing of quayside, part stores/warehousing and office space at the port base. Supporting services such as bunkering and berthing will usually be purchased from the port operator as part of a long-term contract. If the project owner adopts a "hands-off" approach then it is possible that the wind turbine OEM will take full responsibility for the onshore facilities, including the establishment of a service base as part of their capital supply contract. This route can help facilitate activities during the commissioning phase of the project.

Offshore logistics

Under the "hands-on" approach the owner will take on management of the majority of the offshore logistics. The primary driver of doing so is that some owners feel that the limited liability within the service contract with the OEM can never fully cover the potential downtime risk faced by the owner. Greater upsides are therefore achievable through better optimisation of marine logistics and O&M activity, but this has to be balanced against far greater risk, which makes it only really an option for those highly capable operators (usually with substantial offshore oil and gas experience). This choice will also determine which party takes responsibility for the so-called weather risk in the wind turbine OEM contract – that is the party that bears the opportunity cost of turbine downtime below a certain level due to weather interruptions. It clearly makes sense for whoever takes on the weather risk to also have control over the offshore logistics.

The majority of service vessels are contracted by the owner on a long-term lease from specialist marine contractors, although some may own a small number of vessels directly. The owner would then decide where and when to go with the contractor providing the shuttle service to the turbine. Both boat building and marine contracting are areas where smaller UK companies have broken into the market already.

For major interventions requiring the transport of heavier components (> 500-2000kg), larger vessels and jack-up barges are generally contracted in by the owner, either on long-term lease or from the open market. However, there are examples of owners buying vessels (RWE), or in the case of DONG, strategically investing in a marine contractor – though these moves are primarily aimed at providing installation capacity rather than resources for O&M. As offshore wind projects increase in size, the economic rationale for having a jack-up vessel permanently on site will increase.

It is still relatively early days for the use of helicopters in offshore wind but for those projects that have used them the owner or OEM (depending on the model) has sub-contracted a specialist helicopter operator to transport personnel to and from the project site. It is unlikely that owners or OEMs would choose to buy helicopters outright at this stage.

Offshore-based operations utilising motherships, fixed platforms or offshore support vessels are so far limited to a few pioneering sites outside the UK. Therefore a contracting regime has yet to emerge for this logistical strategy. As the need for such a strategy increases, opportunities will emerge for experienced offshore

logistics providers to enter the value chain, contracting either with the wind turbine OEM or the project owner.

Looking forward to further offshore sites with two or more turbine types, there is potential for greater cooperation between OEMs in the form of shared logistics, be this helicopters or vessels, provided by a third party. This would echo best practice in the oil & gas sector whereby multiple OEMs utilise a helicopter shuttle service to oil rigs.

If a more conventional “hands-off” approach is adopted by the project owner, the wind turbine OEM would take responsibility for all aspects of turbine maintenance and would also lead on marine logistics.

Turbine maintenance

The operation of turbines has four main elements: inspections, scheduled and unscheduled maintenance, provision of spare parts and training of technicians. Under the terms of the warranty, the OEM will have an almost complete monopoly on turbine maintenance and will undertake all of these roles. However for those “hands-on” operators looking to up-skill, and in due course take over, owners may look to undertake joint working with the OEM, for instance by the owner hiring technicians who then work for the OEM on a secondment basis.

Post-warranty there is more scope for the owners to be involved in aspects of turbine maintenance including inspections, some types of scheduled maintenance and training of technicians. However, due to sensitivities around Intellectual Property (IP) and technical knowledge required, it is likely that the OEM will remain contracted in a smaller role focusing on more complex and unscheduled maintenance.

In terms of parts, there is currently a limited spares market beyond the OEMs and in the short-term at least, OEMs are likely to be involved in providing spares. However, owners have expressed some dissatisfaction at the cost, quality and lead times required for even quite basic spare parts such as lubrication oil and are keen to see a spares market emerge. In theory this should be relatively easy to achieve given that the OEMs are largely assemblers of a strong supply chain whom could be contracted directly. However, the OEMs may seek to inhibit this process, perhaps through long term agreements with their partners, and barriers around IP and quality assurance remain.

Export cable and grid connection

The OFTOs have three main assets to manage: onshore substation and associated work, export cable and offshore substation. For offshore and onshore substations, transformers and associated equipment, manufacturers tend to pass on the warranty they receive from their sub-suppliers to the OFTO, with no overarching warranty provided for the project electrical system as a whole in most cases.

As most OFTOs are financial investors with emerging offshore experience and limited desire to undertake the actual maintenance activity, the work will typically be sub-contracted to another party. This could be the electrical OEM, a third party, or as we have seen to date, to the owner of the wind farm itself. The owners may have an incentive to bid for this work to retain control over maintenance of an asset critical to getting the wind farm’s output to market. The OFTO would then own the transmission connection, but contract the wind farm owner to manage it.

In terms of the export cable, the sector is starting to see some innovation in maintenance strategies by OFTOs with Transmission Capital signing a maintenance agreement with Global Marine Systems. However, practice is still relatively immature compared to other comparable sectors such as telecoms.

Array cable maintenance

Subsea cables usually come with a 5 year warranty. However this is usually only to cover manufacturing defects. The main issues for array cables relate to movement of the cable, exposure by tides or sediment flows, and in extreme cases failure due to anchor strike or external aggravation, none of which will be covered by warranty. The owner is therefore responsible for monitoring and surveying the cable and repairing it when required, although cable maintenance strategies are still fairly immature in this industry. The survey work and remedial work is likely to be sub-contracted to a specialist provider.

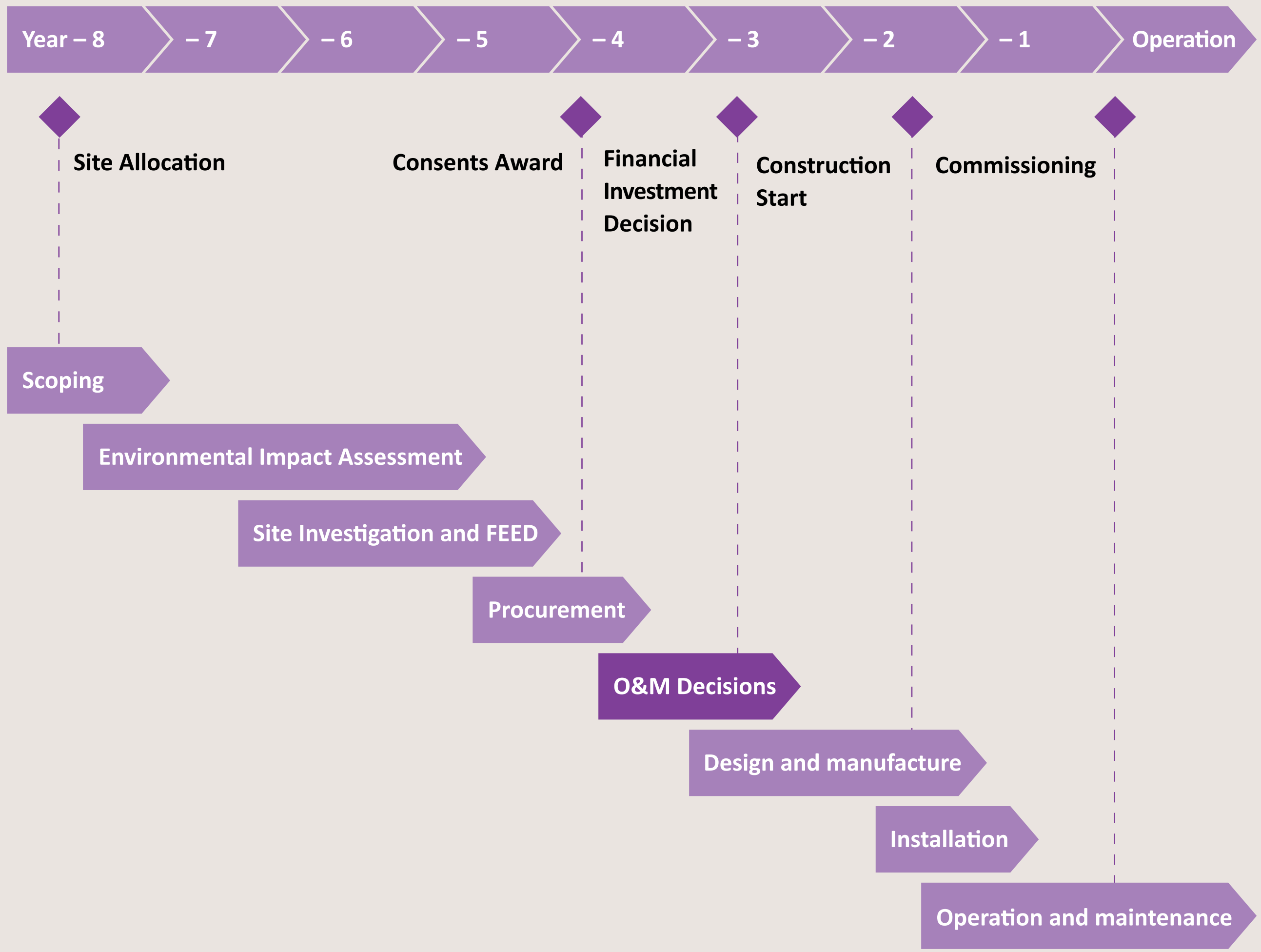
Foundation maintenance

In contrast to turbines, foundations are not generally covered by any form of warranty. Instead foundation risks are to some extent insurable and mitigated through certification. The maintenance is therefore of a different nature, composed largely of visual inspections and survey work with remedial work completed when required. Inspections are undertaken on structural strength, lifting, climbing and safety equipment, corrosion and scour protection, where applicable. This work is generally the responsibility of the owner, although may be sub-contracted either to the foundation provider or installer, or more likely, a specialist third party provider.

Back office, administration and operations

As the owner has overall responsibility for managing the wind farm, they will always undertake a number of management and back office roles to achieve this. This includes analysing supervisory control and data acquisition (SCADA) data, IT support, health and safety and general admin support.

Figure 4.2: Indicative project timeline



A wide range of goods and services are required across the lengthy development phase

Timing

The key decisions on the O&M strategy are usually only made quite late in the development process, particularly under the “hands-off” approach. Although owners will start considering options and strategies for O&M earlier in the development process, they are likely to only be confirmed once the turbine OEM has been identified. This is because of the critical role that OEMs play in O&M. At the point when the financial investment decision is made, the owner and/or OEM will have identified the O&M strategy and be in the advanced stages of planning with the host port. The actual operational details of the strategy, which may trigger certain sub-contracts to be let, may be confirmed at an even later stage.

Figure 4.2 illustrates the approximate timing of the key decisions associated with the O&M arrangements for a typical offshore wind project, and therefore at what stage a potential new entrant supplier might consider actively targeting clients. As can be seen, this can be up to four years before the actual start of operations and so it is important that a long-term view of the project pipeline is taken when considering marketing activity.

5 Conclusions

The UK offshore wind sector is growing rapidly and with it a huge market for Operations & Maintenance (O&M) services is emerging. In this document, we have presented a guide designed to outline the most important aspects of technical and commercial practice in this market, now and into the future. For those companies considering opportunities for participation in this space, some key messages from this document are summarised below.

1. The market for offshore wind O&M services is expected to grow to £1.2 billion/year by 2020 and almost £2 billion in 2025 – in the UK alone. This represents a five-fold increase on today's level. By the end of the decade there will be up to 4,000 wind turbines and 50 offshore substations requiring O&M in the UK.

2. The offshore wind business has not yet reached commercial maturity which means that there is a wide range of technical and contractual approaches to consider. This complexity will increase as projects are constructed further from shore, which presents both challenges and opportunities for incumbent and new entrant contractors. Innovation and commercial flexibility will be required for success in this space.

3. After considering Health, Safety and Environmental (HS&E) and training requirements, O&M provision is, and will continue to be, driven by project economics – minimising spend on the one hand and lost revenue on the other. Companies that bring solutions to the market which are safer, reduce costs and boost revenue will be well placed to succeed.

4. In common with all other sectors of the offshore wind industry, reducing the cost of energy from offshore wind farms is a primary focus for O&M.

5. The required O&M services are contracted by three main actors: project owners, wind turbine original equipment manufacturers (OEMs) and offshore transmission owners (OFTOs). These players are driving a wide range of contractual and strategic approaches to offshore wind O&M, underlining the need for commercial flexibility for contractors targeting this evolving and relatively fragmented market.

6. The key decisions on the size and shape of O&M provision for a particular project are made over a 2-3 year period spanning the award of construction consents through to, and after, financial investment decision in the project. The earlier a provider is involved in shaping the solution for the project the better the chances of commercial success. However, the opportunity to win contracts on established projects should not be ignored, particularly as the main equipment warranties expire at the end of year 5 of operation, representing a possible entry point for new providers.

7. Opportunities for new entrants to the industry exist in several areas most notably where existing practice lacks maturity or will be unsuitable for future projects constructed further from shore and in harsher environments. Notable areas for consideration include improved offshore logistics, vessel leasing and subsea operations.

8. Small and Medium Enterprises (SMEs) are particularly well suited to exploit opportunities that require a local presence, commercial/technical flexibility or specialist/innovative solutions. Several UK SMEs have already been successful in this market but there is considerable scope for further involvement.

9. Offshore wind operation and maintenance shares many challenges with parallel industries from which lessons may be learned. For example, the activity takes place in the same tough offshore environment as oil and gas inspections, repair and maintenance (IRM) and the industry structure and market scale is not dissimilar to the UK passenger aircraft maintenance, repairs and operation (MRO) business. But offshore wind O&M is driven by unique economic pressures, which means that entirely new models and modes of operation will emerge as the sector matures.

10. As this industry looks at the challenges ahead and strives for commercial maturity, it is those companies who actively engage now that will help to shape its future.

6 Outline work packages

The following pages provide useful information on offshore wind O&M work packages along with the challenges and opportunities they present.

1. Onshore logistics

An O&M port base will always be required. It is standard practice to co-locate the offices, parts store and quayside facility. If required, helicopter facilities, such as a landing pad, refuelling facilities and hangar, are generally located nearby to allow technicians easy access to the helicopter or vessel. The primary location drivers are typically distance from the site and minimal marine access constraints (such as locks or draught restrictions). Other drivers include availability and appropriateness of existing facilities as well as onshore access and infrastructure.

For most operations, a minimum draught of 2m is adequate for workboats and other small vessels. At least four berths are usually required. Whilst it is often convenient to be able to dock larger vessels, such as so-called 'floatels' or jack-up vessels, in the same location the reduced frequency of visits from such vessels means that these can be mobilised or re-stocked at alternative, more distant ports.

Example current providers: Associated British Ports, Port of Mostyn, Local Authorities (eg. Thanet District Council – Port of Ramsgate)

Indicative project spend: £400,000 to £700,000/yr for 500MW wind farm

Challenges and opportunities

- Port location is critical – far from shore port requirements will differ from workboat only
- Scope for future expansion to support additional project phases
- Flexibility to accommodate variable demand with maintenance campaigns etc.

2. Workboats

Workboats are an essential part of any shore-based offshore wind O&M strategy. Providing the backbone of logistical services, these vessels transport technicians and equipment from the shore to the wind farm. Far offshore sites may also use workboats to ferry technicians between the offshore base and turbines.

Current workboats are stable catamaran vessels of the order of 12-24m length overall (LOA) with a passenger capacity of approximately 12. They can typically work up to 1.5m significant wave height and are usually classified as MCA Category 2 – limiting them to 60 NM from base. The cruising speed of the current fleet is in the range of 20 to 25 knots. It is standard practice for supply of workboats, skippers and mates to be contracted to an operator on a long-term basis.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The superior speed and stability of Small Waterplane-Area Twin Hull (SWATH) vessels and other novel designs may increase the range of workboat-only O&M strategies where regulatory or other factors limit the use of helicopter support.

Example current providers: Windcat Workboats, MPI Workboats, C Wind

Indicative project spend: £2,000,000 to £3,000,000/yr for 500MW wind farm

Challenges and opportunities

- Increasing accessibility (sea state conditions in which safe access to turbines may be achieved) through novel access devices and improved vessels
- Increased speed of vessels combined with comfort of passengers who may be spending four hours a day transiting
- Regulatory change to allow more than 12 passengers per vessel. Issue currently being discussed at the International Maritime Organisation (IMO)
- Improving fuel economy (currently around 30% of vessel budget is spent on fuel)

3. Aviation

Helicopters transport technicians to and from the wind farm. They allow access in otherwise inaccessible sea state conditions and their high speeds and low carrying capacity fits well with the dispersed nature of offshore wind projects and the high frequency/low effort interventions that make up a large proportion of offshore visits.

To date helicopters have mainly flown to and from the wind farm rarely landing on the offshore substation, with technicians being winched down to the turbine. For this type of work, small four to six passenger helicopters have been used, such as the EC135, ferrying one or two crews each of two to three technicians between the onshore base (or nearby airfield) and the offshore turbines or substation.

In the event of crews based offshore, a larger helicopter may act as a "bus" transporting a larger number of technicians to a single point in the wind farm, mirroring the approach used in oil and gas.

Helicopters are normally contracted on a long term basis, with either exclusive or shared access to the aircraft.


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Example current providers: Bond Air Services, Bristow Group, CHC Helicopters

Indicative project spend: £1,500,000 to £3,000,000/yr/aircraft (typically one aircraft per project)

Challenges and opportunities

- Visibility and cloud-base can restrict operation, particularly for hoisting operations
- Consent may be hard to gain for many projects or locations
- Perception, particularly with regard to safety implications
- Keeping costs down (e.g. asset sharing) whilst guaranteeing access to the aircraft during periods of onerous sea-states

4. Crane barge services

Replacement of large or heavy items will require a crane barge service to ensure sufficient stability during lifting operations. These have typically been jack-up vessels but floating dynamically positioned or anchor spread supported vessels can also be used. Vessels are needed for major turbine repair operations and repairs to offshore substation components such as transformers.

For the purposes of O&M, vessel lifting capacity is typically less of an issue than operational water depth and crane under-hook height, since most components are unlikely to exceed 100 tonnes at most.

Example current providers: A2Sea, Hochtief, MPI Offshore

Indicative project spend: £4,000,000 to £12,000,000/yr for 500MW wind farm (average spend)

Challenges and opportunities

- Ideally need small jack-ups with relatively low lift capacity, but high crane reach and deep water capabilities
- Negotiating call-off, framework or sharing agreements wherein lead times may be minimised without incurring ownership costs to the project


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5. Offshore accommodation/base


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Offshore accommodation, although expensive, might be needed if the project is located more than about two hours transit by workboat from the O&M port. Offshore-based strategies can be split into two primary types: fixed or floating.

Fixed offshore accommodation is likely to echo offshore oil and gas accommodation platforms and requires workboats or a helicopter to shuttle technicians and parts to the wind turbines.

Whilst more susceptible to onerous weather, floating accommodation, such as floatels or motherships, has the benefit of mobility and may be able to deploy smaller vessels in benign conditions or utilise a heave-compensated offshore access system (such as Amplemann) directly from the accommodation vessel in more onerous sea states.

Example current providers: Chevalier Floatels, Esvagt, SeaEnergy PLC

Indicative project spend: £10,000,000 to £20,000,000/yr for 500MW wind farm

Challenges and opportunities

- Fixed accommodation lends itself to helicopter transfers, but this would require additional infrastructure such as refuelling, emergency response capabilities and meteorological infrastructure
- Currently limited deployment and recovery systems for mobilising craft from fixed or floating accommodation
- Limited access methodologies from offshore service vessels (OSVs) to the wind turbine

6. Turbine maintenance

Maintenance can be divided into preventive (scheduled) and corrective (unscheduled) works. The bulk of preventive works will typically be carried out during periods of low wind speeds to minimise the impact on production, however, in practice, this is not always achievable. Corrective maintenance is performed in response to unscheduled outages and is often viewed as more critical, due to accruement of downtime until the fault is resolved.

The primary skills required are mechanical or electrical engineering, with further turbine-maintenance training often provided by the relevant turbine provider. Offshore survival, working at height and climbing skills are also a prerequisite.

Additional specialist skills are often valued within a team of turbine technicians, including high-voltage equipment training, certification to undertake lifting and climbing equipment inspections and rope access training.

Example current providers: Turbine OEMs, Project Owners

Indicative project spend: £2,000,000 to £8,000,000/yr for 500MW wind farm

Challenges and opportunities

- Improving reliability
- Turbine supplier monopoly during warranty period
- Potential future scope for third-party service providers at projects which have come out of warranty
- Strong skills and training demand


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7. Turbine spare parts

During the warranty period, it is normal for all spare parts to be sourced by the turbine supplier. However, once out-of-warranty, the project owner may have the freedom to seek alternative suppliers for some of the more generic components and consumables, especially since turbine suppliers purchase in the majority of their components from sub-suppliers.

The cost of lost revenue due to down-time means that a well-kept project should not suffer significant delays due to parts shortages. Large replacement components can often be taken off the turbine production line – meaning that the greatest source of delays when a replacement is needed is the lead time required to get a jack-up on site.

All rapid turnover parts and consumables can be expected to be stored in a large warehouse requirement at onshore base.

Example current providers: Turbine OEMs (Siemens, Vestas, RePower et al), Third-party suppliers

Indicative project spend: £3,000,000 to £6,000,000/yr for 500MW wind farm

Challenges and opportunities

- Apparent turbine supplier monopoly, particularly during warranty period
- Scope for sourcing direct from sub-suppliers or third parties
- Good parts management and stocking is of vital importance to owners
- Long term availability of parts for discontinued products


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8. Offshore substation maintenance


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Maintenance of the offshore substation primarily consists of non-intrusive inspections of topside switchgear and transformers infrequent intrusive services or repairs, and foundation and topside structural inspections.

There is also the need to carry out paint repairs and secondary steelwork repairs (railings, gratings, gates, stairs, ladders etc).

More serious repair operations such as replacing transformers will require the use of heavy lift vessels.

Maintenance of the offshore substation is typically the responsibility of the OFTO although they may sub-contract this work.

Example current providers: High voltage electrical contractors such as Siemens, ABB or Alstom, wind farm owners

Indicative project spend: £50,000 to £200,000/yr for 500MW wind farm (average spend)

Challenges and opportunities

- Largely specialist work
- Strong demand for technicians with high-voltage experience

9. Export cable surveys and repairs

Export cable surveys are mostly required to check the cable burial depths – particularly at sites where fishing (which can disturb buried cables) is commonplace. The frequency of surveys will depend heavily on seabed mobility and results of the initial surveys. Surface-based surveys can be used to detect significant cable exposure, but ROV surveys will be required for more accurate burial depth data.

Insufficient burial or cable exposure is typically resolved by remedial measures including protective mattressing and rock dumping, normally using a dynamically positioned fall pipe vessel, or occasionally side-dumping vessels. Export cables can fail either due to defects or external aggravation, such as anchor or fishing strikes.

Cable repair will normally require a full cable laying spread consisting of a cable laying barge with cable plough or jetting equipment.

Export cable failures may result in complete loss of the wind farm's output. For this reason, maintenance and surveys of this asset are likely to be the subject of greater urgency.

Example current providers: VSMC Visser Smit, Global Marine, Pharos, Technip, OMM

Indicative project spend: £50,000 to £200,000/yr for 500MW wind farm (average spend)

Challenges and opportunities

- Cable repair strategies are still relatively immature compared to other comparable sectors (e.g. telecoms)
- Mostly within the realm of large offshore contractors
- Scope for some smaller survey vessels (either surface or using ROVs)

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10. Onshore electrical

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Onshore substation maintenance comprises non-intrusive inspections of switchgear, transformers and any reactive power compensation equipment. Infrequent intrusive servicing and repairs may also be required.

Unlike many of the systems of an offshore wind farm, the onshore substation is almost entirely non-offshore wind specific – consisting of standard high-voltage electrical equipment.

Onshore cables are generally very reliable and require little scheduled maintenance. On occasion, faults may arise that require spare length of cable, jointing equipment and a small excavator (if buried).

Example current providers: High voltage electrical contractors such as Siemens or ABB, Owners

Indicative project spend: £20,000 to £100,000/yr for 500MW wind farm (average spend)

Challenges and opportunities

- Largely specialist HV work
- Skills: there may be challenges meeting the strong demand for technicians with high-voltage experience

11. Array cable surveys and repairs

The array cables are the electrical cables installed beneath the sea bed to connect the turbines to the offshore substation. The physical requirements of surveying and repairing the offshore wind farm power array cables are very similar to those of export cables (see work package 9).

The downtime associated with an array cable failure is of a different magnitude and so response times may be slower.

Example current providers: Specialist cable, rock dumping and ROV contractors, Boskalis, DEME

Indicative project spend: Highly variable with seabed conditions and number of failures. Indicatively £200,000 to £500,000/yr for 500MW wind farm (average spend)

Challenges and opportunities

- Mostly within the realm of large offshore contractors
- Scope for some smaller survey vessels (either surface or using ROVs)

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12. Scour and structural surveys

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Activity needing sub-sea operations may include infrequent structural and J-tube cathodic protection inspections and can generally be carried out using remotely operated underwater vehicles (ROVs). Diving, although currently relatively commonplace, is required only in exceptional circumstances and efforts are being made to maximise the use of safer, remote techniques.

A range of specialist surveys are required to ensure the structural integrity of the turbine foundations. Routine surveys are likely to be undertaken in the first two years but once the site has been characterised, subsequent surveys are very infrequent, with many works required on a five or ten year cycle.

Surveying the status of the protection installed to prevent sediment erosion where the turbine foundation meets the seabed (scour) can be carried out by side-scan sonar from a survey vessel.

Surface inspections and surveys include monopile internal inspections of the grouted connections and splash-zone inspections.

Example current providers: Various specialist contractors such as Fugro

Indicative project spend: Very project dependent, indicatively £200,000 to £600,000/yr for 500MW wind farm (average spend)

Challenges and opportunities

- Improving understanding of secondary scour
- Specialist equipment and skills required infrequently – a large volume of operational wind farm capacity required to enable investment in dedicated equipment

13. Foundation repairs

Maintenance of the structure of the turbine foundation and transition piece may involve various activities. Regular maintenance includes repairing the paintwork (especially on the boat landing) and cleaning marine growth.

More significant works can include repairs to grouted joints (unlikely to be needed in the future), rock placement to augment scour protection and intermittent repairs to wave-damaged secondary steelwork such as ladders, gates, grills and platforms.

Other systems installed on the foundation such as low-level navigation and sign illumination lights will also need to be maintained.

Example current providers: Various specialist contractors depending on scope

Indicative project spend: Very project dependent, indicatively £100,000 to £600,000/yr for 500MW wind farm (average spend)

Challenges and opportunities

- Specialist equipment and skills required infrequently – a large volume of operational wind farm capacity required to enable investment in dedicated equipment
- Ensuring sufficient redundancy of navigational lighting and ease of supply chain for replacement parts

14. Lifting, climbing & safety equipment inspections

Inspections of safety-critical devices including:

- Fall arrest systems
- Davit cranes
- Boat landing and ladders
- External gates and railings
- External evacuation equipment

Inspections must be carried out by qualified personnel, either as part of the primary turbine maintenance works or by a team of independent inspectors. Inspection frequency will be six-monthly or annual, depending on the equipment.

Drills/practices of health and safety incidences should feature as routine during O&M.

Example current providers: Certified maintenance technicians, Specialist inspectors

Indicative project spend: £100,000 to £200,000/yr for 500MW wind farm

Challenges and opportunities

- It is likely that most owners will seek to train up a number of their own technicians for these roles as they are frequent but require minimal time
- Potential scope for independent certifiers to provide these services, but unlikely to be a full-time role unless spread across multiple projects
- Owners will seek to perform inspections in the summer months to minimise likelihood of weather delays

15. SCADA and condition monitoring

Operating a wind farm depends on supervisory control and data acquisition (SCADA) monitoring, which is used to optimise wind farm performance and, potentially, identify component faults. In addition to the 24/7 monitoring and occasional remote manual intervention, which requires several dedicated personnel per wind farm, data can also be analysed in depth off site for condition monitoring purposes.

Example current providers:

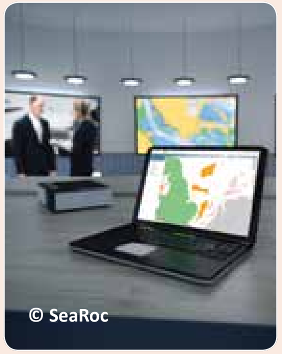
- Operations and monitoring activity generally performed by the turbine supplier or the wind farm owner
- Condition monitoring analysis can be carried out by specialist third parties or consultancies

Indicative project spend: £400,000 to £800,000/yr for 500MW wind farm

Challenges and opportunities

- Improving plant condition monitoring equipment and algorithms to interpret early onset of component failures
- Increasing offshore wind data set

16. SAP and marine co-ordination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Management and coordination of O&M activity is important to wind farm safety and efficiency. A senior authorised person (SAP) is needed on-site at all times with coordination responsibility for switching of all high voltage equipment.

Marine coordination involves the 24/7 monitoring of the locations of all vessels and personnel within the vicinity of the project, including the interpretation of specialist tools such as marine coordination software.

There is a need to make judgements about the priority of activities based on the scheduled and unscheduled maintenance workload and weather forecast.

Example current providers: SeaRoc, Windandwater.dk, Atlas Services Group

Indicative project spend: £400,000 to £800,000/yr for 500MW wind farm

Challenges and opportunities

- Bigger wind farms further offshore will increase the logistical challenge
- Move to HVDC cables

17. Weather forecasting

As well as impacting the power production from the turbines, the prevailing weather conditions have a very substantial impact on wind farm O&M.

Daily site-specific forecasts of wind speed, wave conditions, atmospheric pressure, precipitation, temperature and visibility – looking 96 hours ahead – are used to plan maintenance visits and other activity.

Example current providers: UK Met Office, MeteoGroup

Indicative project spend: £40,000 to £90,000/yr for 500MW wind farm

Challenges and opportunities

- Improved accuracy of influence of site specific factors
- Incorporation of feedback data from site to improve forecasts


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18. Administration

As with any commercial activity, a range of administrative tasks must be completed in support of offshore wind O&M. The various tasks include financial reporting, public relations, procurement, parts and stock management, H&S management, “permit to work” controls and general administration.

Also, training must be carried out and subcontracts organised. Some of the activity will need to be carried out ‘in-situ’ at the port base, but much back-office support can be done at a remote location such as company headquarters.

Example current providers: Generally carried out by the wind farm owner

Indicative project spend: £200,000 to £500,000/yr for 500MW wind farm

Challenges and opportunities

- Staffing O&M port base, which may be in a remote or sparsely populated region
- Securing appropriate premises

Further information

Centres for offshore renewable engineering (COREs)

For England, further information about business and investment opportunities may be found at COREs which are partnerships between central and local government and local economic partnerships. They are designed to ensure businesses looking to invest in manufacturing and services for the offshore renewables industry receive the most comprehensive support possible.

Great Yarmouth & Lowestoft CORE: Eunice Edwards
eunice.edwards@newanglia.co.uk

Humber CORE: Richard Kendall
r.kendall@humberlep.org

Kent CORE: Peter Symons or Sue Mills
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Liverpool CORE: Mark Knowles
mark.knowles@liverpoollep.org

North Eastern CORE: Helen Golightly
helen.golightly@nelep.co.uk

Tees Valley CORE: Steve Pugh
steven.pugh@teesvalleyunlimited.gov.uk

Devolved Administrations

For Scotland, Northern Ireland and Wales, the enterprise functions of the devolved administrations have responsibility for generating business and attracting investment in offshore renewable energy. Further information about business and investment opportunities is available from the devolved administrations or their enterprise agencies:

Scottish Enterprise: Ian McDonald
offshorewind@scotent.co.uk

Highlands and Islands Enterprise: Elain MacRae
renewables@hient.co.uk

Invest Northern Ireland: Sam Knox
sam.knox@investni.com

Welsh Government: Mike Barcroft
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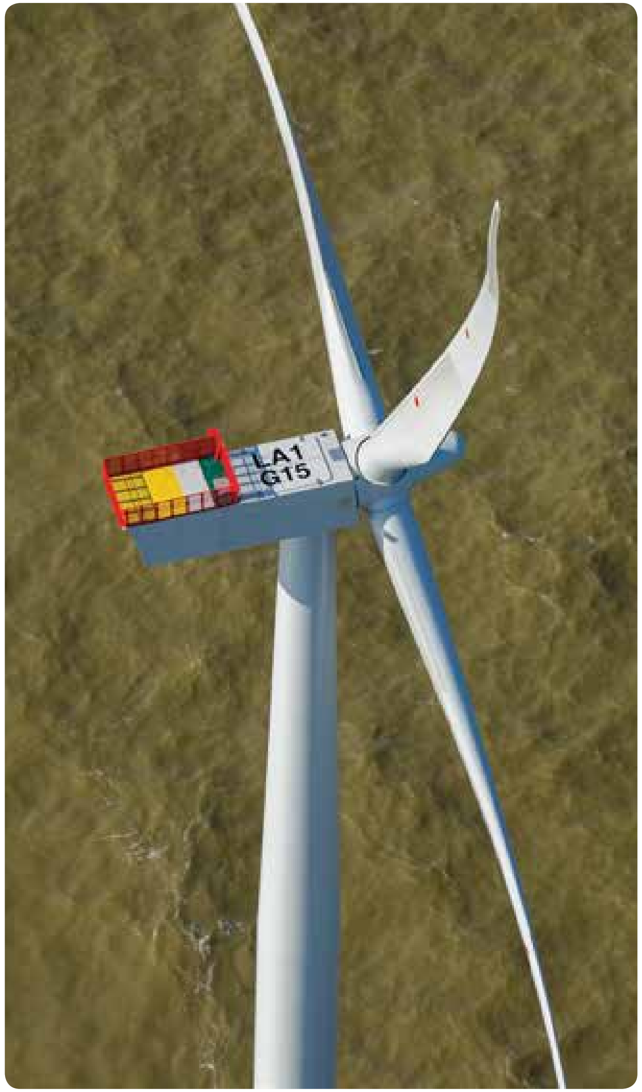

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