Introduction

This paper discusses the challenges frequently encountered by new suppliers entering the offshore wind operations and maintenance (O&M) sector, and the UK market in particular. Technology development, testing, validation, and demonstration, as well as business case support, are some of the ways in which the Offshore Renewable Energy (ORE) Catapult can help innovators to access this growing market – we have drawn on our experience in doing so to share knowledge in this paper. Readers will be given an introduction to the industry, and should gain an understanding of who the key stakeholders are, how they are motivated, and some of the dynamics that are important to understand when considering working in offshore wind.

Headlines

• The provision of O&M services to the offshore wind sector is a relatively new business area. As an organisation, the Catapult frequently encounters innovators and new entrants from a broad spectrum of backgrounds who are keen to gain a foothold.

• Coupled with this, the anticipated continual steady growth in the size of this market may make it an attractive option for those looking to innovate or diversify. The current UK installed capacity is 7.8GW with a realistic projection of at least 10GW by 2020, and over 30GW if all consented projects are constructed.

• There are some barriers to entry, and distinct properties of offshore wind farms that are worthy of consideration.

• Demonstration opportunities are important chances to develop technology, people, and track record, as well as a way to attract investment.

1 Figures from RenewableUK, March 2018
UK Offshore Wind: Market Overview

Offshore wind is a maturing industry in the UK. Significant capacity has been installed across around 35 operational projects over the last decade or so. At the time of writing there are at least 1900 operational offshore wind turbines in UK waters, representing an installed capacity of over 7.8GW with a considerable volume of construction underway. Offshore wind now represents a significant proportion of all infrastructure investment in the UK. In the next few years, the capacity of plant reaching, or beyond the end of, the turbine OEM's (original equipment manufacturer) initial warranty of usually five years will grow steadily.

The operations and maintenance (O&M) phase of an offshore wind project represents around 25% of the total project value. This phase of the project represents the most significant opportunity for local content contribution, and at the same time offers newcomers a relatively low barrier to entry. Combined with existing skills and experience, complimented by those from other industries, there are significant opportunities for new businesses and expansion in offshore wind in the short-to-medium-term in the UK. The techniques used and level of experience continue to evolve as the industry grows in scale and maturity.

At present there are significant opportunities to improve O&M practices by becoming more proactive and data-driven in conducting maintenance: doing more work in a planned way, rather than at short notice in a reactive manner. Improvements in the health and safety of offshore personnel through technology and by decreasing their exposure or number of trips required are also achievable in the medium-term. The industry continues to strive for improved reliability as a means of improving efficiency and profitability.
Coupled with the UK’s world-leading installed capacity, there is also a strong pipeline for future development – including projects in construction, those with consent but yet to achieve financial investment decision (FID), and more again in development.

Status of UK offshore wind projects

Figure 2: UK offshore wind capacity added and capacity out of warranty.

Figure 3: Capacity of UK offshore wind by project status.
Progression to Commercial Viability

UK offshore wind projects are almost exclusively owned and operated by multinational organisations. Most commonly these are large utility companies, although it is acknowledged that there are noteworthy exceptions and that business strategies around offshore wind operations may be evolving as assets mature. Furthermore, some previously distant players are demonstrating a serious interest in diversification to offshore wind – particularly well-established oil majors. Nonetheless, as in many industries, it can be challenging for those with innovative ideas or new businesses to gain a foothold and build a credible track record.

One of the most commonly described challenges is for businesses who seek to take their service or solution from something which is viable on paper or in a laboratory environment to commercially viable. This area of challenge is the focus of the Catapult network: ORE Catapult specialises in supporting innovators to progress their new offerings to a stage where they may be considered commercially viable. As an organisation we are dedicated to working with companies who aim to provide new services or solutions to bridge the gap between research and commercialisation, by providing technical support, advice, applied research, test, validation and demonstration opportunities, including working with potential end customers such as Owner/Operators and OEMs.

Technology Readiness Level (TRL) is commonly used to define progress on the journey from research to commercialisation; definitions are shown in Table 1.

<table>
<thead>
<tr>
<th>TRL 1</th>
<th>Basic principles observed and reported.</th>
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<tbody>
<tr>
<td>TRL 2</td>
<td>Technology concept and/or application formulated.</td>
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<tr>
<td>TRL 3</td>
<td>Analytical and experimental critical function and/or characteristic proof-of-concept.</td>
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<td>TRL 4</td>
<td>Technology basic validation in a laboratory environment.</td>
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<td>TRL 5</td>
<td>Technology basic validation in a relevant environment.</td>
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<tr>
<td>TRL 6</td>
<td>Technology model or prototype demonstration in a relevant environment.</td>
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<tr>
<td>TRL 7</td>
<td>Technology prototype demonstration in an operational environment.</td>
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<tr>
<td>TRL 8</td>
<td>Actual technology completed and qualified through test and demonstration</td>
</tr>
<tr>
<td>TRL 9</td>
<td>Actual technology qualified through successful mission operations.</td>
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Table 1: Description of Technology Readiness Levels (TRL)
The Catapult’s part in the journey is focused on bringing research and development ideas closer to fully-viable commercialisation – between TRLs 5 and 8. An example of the progress that can be made through this innovation to commercialisation journey is the collaborative work between the Catapult, Turner Iceni and Sensor-Works. In response to an open call to participate in technology demonstrations, Sensor-Works and Turner Iceni expressed an interest in developing their technology by deploying it on the Catapult’s 7MW Levenmouth Demonstration Turbine. The Catapult was able to facilitate collaboration between the two companies, culminating in the installation of a prototype wireless vibration monitoring system in the turbine. This has enabled the companies to prove their technology, develop a track record, and de-risk future applications by working in a realistic offshore wind turbine environment.

**Market Dynamics and Barriers to Entry**

If a company has an innovative idea that they believe may have a market in offshore wind, what should they do to build their business?

In providing support to new entrants, the majority of the questions fielded by the Catapult tend to fall into the following key categories:

1. What are the most common barriers to entry?
2. Who are the key stakeholders to consider?
3. What are the similarities and differences between offshore wind and other industries?
4. What are the requirements around building a track record of a new concept through demonstration?

Let’s look at these areas in turn.

**Common Barriers**

*Cost incompatibility*

Solutions that may work, for example, in a centralised, permanently manned and long-established offshore oil and gas system may not necessarily be economical in offshore wind. At the most fundamental level, if a new system or service can compete or reduce costs compared to what represents current industry practice in offshore wind, then it may begin to look attractive to an operator. If a new solution or service is significantly more expensive, then other benefits must be evident if potential customers are to be encouraged to consider new entrants. The Catapult offers support and commercial validation to those considering an application in offshore wind.

*Risk profile*

The appetite for risk – including commercial, technical, environmental, and to health and safety – may be fundamentally different between a large, multinational operator and a supply chain innovator. A perception of any increase in risk may serve as a barrier to engagement with a wind farm operator. Development of credibility based on a solid track record is important in this regard. The cost of risk – for example, the perception of a new solution by an insurer or project financier – should also not be underestimated.
Innovation fatigue and selection

Relatively speaking, the size of the workforce tasked with the day-to-day operation of an offshore wind farm may be small. The operation is complex and interrelated in nature, with many activities having knock-on cost and time implications for other parts of the system or team. In common with many industries, operational staff are generally incentivised to remain highly-focused on delivery against their longstanding key performance indicators. Understandably, it may be challenging to convince the teams who would use them of the value of investing time and effort in accommodating unproven services or solutions which may jeopardise their performance or add risk.

Key Stakeholders to Consider

When considering an approach to the offshore wind industry it is worthwhile considering the categorisation of the audience. Broad categories include:

Financiers

Organisations financing offshore wind projects could include banks and financial institutions, and also utilities as part of a joint venture or partnership. Generally these organisations will hold a stake without taking an active role in day-to-day operations. These institutions will generally be large and it is highly likely that they will prioritise reduction of risk and stability over almost any other measure of performance.

Operators

The organisation responsible for the day-to-day operation of an offshore wind project will likely be a large utility organisation, although in future it may be that an increasing number of small, agile management organisations emerge as projects grow in maturity. Regardless of scale, these organisations should be anticipated to focus on performance indicators such as: energy production, availability, and overheads or running costs. As above, any move away from business as usual needs to be presented as a well-proven and cost-efficient proposition.

Turbine OEMs

An obvious key stakeholder in the operation of an offshore wind project will be the turbine manufacturer. In 2016, two manufacturers accounted for all of the offshore wind turbines installed in Europe, and this continuing consolidation of the market is expected to continue in the UK for at least the next five years. Whether or not their equipment is within a warranty and/or service contract will determine these organisations’ contractual obligations and, ultimately, decision making. Some projects will continue long-term turbine OEM partnerships because of the perceived lower risk involved; others will prioritise the self-performing of turbine maintenance tasks in-house with reduced OEM involvement, which has been shown to reduce costs. Accordingly, the turbine OEM will be seen to have varying levels of involvement from one project to the next.

Service providers

Some or all of the O&M tasks may be undertaken by third party or independent service providers. There has been a trend in recent years for partnering and merging of these organisations as they, in general, seek to offer more complete scopes to their clients, the operators. Service providers may be in long-term contracts with operators or called in for individual campaigns, and they may provide general technician resource or provide more niche specialist services.
In approaching either new customers, partners or competitors, it is worthwhile considering how the commercial position of the organisation will influence their behaviour, not least their appetite for risk.

**Similarities and Differences to Other Industries**

**Similarities**

While considering the differing motivations of the various parties above, it may also be worthwhile for potential new entrants to give due attention to some of the fundamental properties of the offshore wind industry; how it differs, and what similarities there are, with other sectors.

Offshore wind farms are complex, industrial working environments. They share common challenges and ways of working with many other industries. Once in the O&M phase, a project operator will likely be seeking to optimise the way that planned and unplanned maintenance is carried out, to reduce their overheads and to maximise availability and production. The streamlining and optimisation of planned maintenance, for example, by either improved logistics or deeper reliance on data and condition monitoring, will be a target for firms in a variety of other industries – particularly those which operate rotating plant.

Technical staff in offshore wind O&M are often mobile and may work at any one site or project for relatively short periods. Whether working for turbine OEMs, Independent Service Providers (ISPs) or as sole traders, they may work on relatively short contracts and also see demand change seasonally. In addition to the high mobility of the workforce – which may be considered similar to, say, construction – offshore wind personnel will require specialist training and certification. Some of that will be transferable and common to other industries, such as oil and gas, whereas others will be based on wind-specific training qualifications and experience. Disciplines of particular relevance and importance to offshore wind include:

- Marine operations.
- Working at height.
- Rope access.
- Composite inspection and repair.
- Rotating machinery, NDT and endoscopy.
- High voltage.
- Lifting operations.
- Other traditional industrial disciplines such as control and electronics, data communications, hydraulics, and mechanical systems.
Differences

Some of the challenges for teams tasked with O&M in offshore wind that are more unique to the sector include:

Weather

Not only is weather a factor in the access and workability of a particular task, as is the case in other industries, but as the input resource it is intrinsically linked to the performance of the plant.

An offshore wind farm’s plant is highly sensitive to weather: production is directly related to the wind speed, and hence full operation is preferred at times of higher wind speeds. From an operator’s perspective, a failure or breakdown during periods of high resource can result in greater losses. Thus, the longer a maintenance task takes, the greater the lost production value. Accessibility and the ability to carry out certain maintenance tasks will also be related to weather conditions. At present, access tends to be restricted by wave height, with the transfer of personnel from a Crew Transfer Vessel (CTV) to turbine often the limiting factor. Lifting operations essential for all but the lightest tasks – either from vessel to Transition Piece (TP) or TP to nacelle – will also likely be limited by wind speed. Technologies and concepts to mitigate these and other influences of weather continue to be developed, not least around Service Operations Vessels (SOVs). However they can come at a significant cost, and as such may not see adoption by projects currently up and running based on existing CTV concepts.

Distribution

Offshore wind turbines are distributed assets. Consider a traditional power station, where a similarly-sized maintenance team works in a central location, with relatively easy access to central stores, management and each other. In contrast, offshore wind turbines will commonly be maintained by small two- or three- person teams, with many of these teams carrying out the same tasks simultaneously but remotely from each other. This presents unique challenges in planning, logistics, supervision, management, quality, communications, connectivity and reporting. Additionally, depending on the commuting time on a vessel, actual working periods once access is taken into account may be relatively short.

It may initially appear relevant to consider offshore wind turbines as volume manufactured and standardised – however, this is not the case. In the area of foundations and seabed in particular, it is likely that no two projects will be the same, and indeed there may be significant variation across even a single site in water depth, ground conditions or scour/seabed mobility – all of which will have implications for O&M. For turbines themselves, even the most commonly deployed are likely to have been produced in numbers of only hundreds for each variant. Whilst it may appear that these are volume manufactured, and indeed many subsystems are, turbines themselves are a low-volume product and hence may also have significant variation in design and build. The synergies and improvements available to truly volume manufactured products – such as may be expected in sectors such as automotive or manufacturing – are more challenging to apply to offshore wind. Another area which shows potential for continued evolution is that of wind farm-wide control. At present, control of turbines will be individual with machines seeking to optimise their own performance.

A more holistic approach, where the control strategy is considered at a site level and incorporates a recognition of both the current market price of electricity and asset life implications of a given control strategy, is likely to emerge in the future and is an area of significant research and development effort.
Design for Maintenance

Finally, the inclusion of a consideration for maintenance and personnel safety at the design phase has evolved over the first decade or so of commercial offshore wind projects. Early projects, in particular where relatively small turbines were deployed, may have significant challenges around access and confined spaces. As the industry has matured and operational experience has fed back into the design of turbines, a more maintenance-friendly working environment has emerged, particularly in the most recent generation of offshore machines. However, even today, projects will deploy products which necessarily include a trade-off between designs optimised for maintenance and minimised initial capital expenditure.

Since there are a number of unique challenges to operating and maintaining an offshore wind farm, potential new market entrants are encouraged to consider how their offering may ease some of the challenges described above. There is much that can be learned to provide more efficient and productive O&M but there is also much that is unique. It is suggested that simply planning to conduct maintenance as it has always been done may not result in either the most productive, or the most profitable operation. There are certainly opportunities to offer benefit to all stakeholders by trying to make space for innovation. As is often the case with innovation, a fundamentally different mindset is required for the full benefit of a new approach to be realised.

Put differently, innovators should consider trying to get some of the things that are unique about offshore wind working in their favour, which may include adopting a radical approach. This may be true for vessel concepts, stores, execution of planned tasks, or studying the performance of the asset deeply and making increasing use of data and analysis. This is a generating plant like few others, as it has a variable resource rather than a capacity that is demand-driven.

Related to the ability to use innovation to drive new services and solutions, it may be pertinent to consider future trends that are likely to influence offshore wind and other industries in the near future:

- Automation and robotics, particularly in the displacement of repetitive human tasks.
- Data and analytics, particularly the deeper and multivariable study of whole system performance.
- Increasing size of turbines. Project dynamics have changed and are continuing to evolve. The ever-increasing rated capacity of offshore turbines will influence O&M in future when planned projects are built.
- There is potential for the supply chain to broaden as some owners proactively seek efficiency by extending their purchasing beyond the turbine OEM only, particularly for sub-assemblies and volume manufactured spares.
- There may be a continued consolidation in the independent service provider market in O&M (turbine OEM consolidation is also relevant). In the future we may see the emergence of a more comprehensive layer of service specialists below major utilities, who in some cases are expected to become increasingly “hands-off” over time.
Technology Demonstration

Demonstration can be an incredibly valuable stage in the development of a new product or service. But accessing the right demonstration environment at the right time can be a challenge, particularly for small companies. Appropriate test, validation and demonstration can:

- Enable new entrants to build credibility and a track record.
- De-risk future activity by accurately assessing the resource and time required.
- Provide a commercially safe way to try something new.
- Give the team involved direct exposure to an unfamiliar working environment.
- De-risk new solutions for potential end customers.
- Help to attract investment.

The opportunity for technology demonstration in a controlled yet representative offshore wind turbine environment is something which the Catapult has been uniquely placed to provide since the acquisition of the Levenmouth Demonstration Turbine.
Demonstrating their technologies at Levenmouth has already helped several UK companies to gain a deeper understanding of the offshore wind industry and offered them a stepping stone to full commercial offshore deployment. The Catapult plans to continue programmes which support innovators in demonstrating their technology in this uniquely representative environment. As an example, the follow-up to the Scottish Government-supported CLOWT (Clone of the Levenmouth Offshore Wind Turbine) project, SMART (SME Asset Research and Testing), offers further research and demonstration opportunity for innovative SMEs with the potential to positively impact the development of the Scottish offshore wind supply chain.

In addition, data is continually being generated by the operation of the turbine, and as such new opportunities are emerging in the development of techniques and services that are data-based.

The Catapult will endeavour to maximise the amount of demonstration opportunities using our assets at Levenmouth and at the National Renewable Energy Centre in Blyth, and work with Owner/Operators to enable demonstration on commercially operating wind farms in collaboration with potential end customers.

Enquiries are welcomed from firms who believe they have a need that could be served by demonstration in this unique, full-scale environment – especially through our Innovation Challenges programme, which highlights the most pressing industry issues in need of fixes. The Catapult can complement any demonstration opportunity with technical support, commercial validation, and business case support to ensure that your new offering is technically and commercially viable, and ready for deployment in the field in an operational environment.

Conclusion

To conclude: it is crucial to know your customers, who they are, and why your product or service is of relevance to them. It is also important to understand the dynamics and drivers of the offshore wind industry and how they will influence your product or service offering. There are limited opportunities to secure that all-important initial test or demonstration, but at ORE Catapult we take pride in our expertise in supporting new companies and technology, testing, validation and demonstration. Finally, there is a large and steadily growing market for offshore wind O&M, which presents a huge opportunity for UK innovators.
Appendices

Recommended Reading
ORE Catapult: Operations & Maintenance Case Studies Series
RenewableUK: Wind Energy Database
ORE Catapult Press Release: £920k Boost to Scotland’s Offshore Wind Ambitions

Author Profile
Owen is a team leader within the Engineering group at ORE Catapult, based in Glasgow. He has been working in the wind industry for the last 10 years across both development and operational sites. Supported by a strong understanding of UK offshore wind O&M, he is also a key member of the team planning and conducting technology demonstrations at the Levenmouth Demonstration Turbine.

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