



Towards Round 3: Progress in building the offshore wind supply chain

An updated analysis for The Crown Estate of the constraints affecting the delivery of UK offshore wind
February 2011

BVG Associates

BVG Associates is a technical consultancy with expertise in wind and marine energy technologies. The team probably has the best independent knowledge of the supply chain and market for wind turbines in the UK. BVG Associates has over 120 man years experience in the wind industry, many of these being “hands on” with wind turbine manufacturers, leading RD&D, purchasing and production departments. BVG Associates has consistently delivered to customers in many areas of the wind energy sector, including:

- Market leaders and new entrants in wind turbine supply and UK and EU wind farm development;
- Market leaders and new entrants in wind farm component design and supply;
- New and established players within the wind industry of all sizes, in the UK and on most continents;
- Department of Energy and Climate Change (DECC), RenewableUK, The Crown Estate, the Energy Technologies Institute, the Carbon Trust, Scottish Enterprise and other similar enabling bodies.

The views expressed in this report are those of BVG Associates. The content of this report does not necessarily reflect the views of The Crown Estate.

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Summary

The Crown Estate leases the sea bed for offshore wind and provides a framework to sustain the UK's leadership of the offshore wind market. It has commissioned this analysis to help a new and rapidly growing industry understand the supply chain challenges that it faces and how they might be resolved. It provides an update to *Towards Round 3: Building the Offshore Wind Supply Chain*, published in May 2009, and is once again based on consultation with developers and feedback from suppliers in key areas.

We forecast that, by 2020, driven mainly by legally binding national renewable energy targets, about 50GW of offshore wind will be installed in Europe, of which around 23GW will be in UK waters. The rate of growth shown in our forecast is consistent with that seen by the wind industry over the last two decades and will require significant new investment right across the supply chain, including in those areas that our analysis suggests are responding well to the opportunity. Without this investment, the industry will neither deliver the desired generating capacity nor the available cost improvements that are necessary for offshore wind to remain the renewable energy technology of choice for large-scale clean energy generation.

Two years ago, we ranked areas of the supply chain with red, amber and green traffic lights, relating to our assessment of the risk of limiting the delivery of installed capacity. We have repeated this approach again (see Table i; see page iv) in order to assess how the industry has evolved.

In 2009, we highlighted the importance of **confidence**, **competition** and **collaboration** within the industry in establishing a European market that is similar in scale to that of offshore oil and gas at its peak. These themes remain and we see positive signs of supply chain progress in a number of the areas that we previously flagged as of greatest concern:

- **Wind turbines.** From a time two years ago when even existing players in offshore wind only had a partial focus on the sector, now we have most of the global top 10 turbine manufacturers either supplying or developing technology specifically to supply the offshore market. They will face competition from a significant number of newcomers, including some of the largest industrial companies in the world. It is clear to us that competition will drive some of these companies to exit or consolidate. The challenge will be to demonstrate the long-term reliability of next generation technology to the satisfaction of those providing finance for projects.
- **Installation vessels.** With a number of new turbine and foundation installation vessels in operation or construction compared with two years ago, we anticipate that there will be sufficient availability for most projects, although there may still be limited supply for projects with the most challenging sea conditions.
- **Subsea export cables.** From a supply base of three experienced players and with relatively high entry barriers, there has been reasonable progress in increasing capacity, for example, with the UK's JDR Cable Systems investing to extend its supply to include high voltage (HV) export cables. We do still need more investment decisions this year in order to keep on track to supply what is needed as the sector grows. It is an area of significant concern among developers and is the single biggest supply chain bottleneck.

A challenge for The Crown Estate and the supply chain, who want to maximise the business opportunities, and for the Government, who wants to maximise the delivery of renewable energy from offshore wind, is unlocking the timely investment required to transition to the industrial scale opportunity afforded by Round 3. We believe that key to unlocking the supply chain investment is a deeper level of collaboration between purchasers and their supply chain; that is, finding the win-win solutions. In our analysis, we flag actions to assist and accelerate such dialogue and improve market stability but, at the heart of progress will be the establishment of deeper confidence between customer and supplier in the next few years as the supply landscape of the industry is set.

Table i. Supply chain status of key areas of the supply chain. ↑ = Situation improved since 2009; → = no change in traffic light category since 2009.¹

Traffic light (trend)	Supply chain area	
G	Environmental impact assessment	Development and consenting
A	Wind farm design	
A	Survey vessel operation	
A ↑	Offshore wind turbines	Turbine manufacture
G →	Blades	
A →	Castings and forgings	
G ↑	Gearbox, large bearings and direct drive generators	
G →	Towers	
R →	Subsea cables (export) ²	Balance of plant manufacture
G ↑	Subsea cables (array)	
G ↑	AC substation electrical systems	
A →	DC substation electrical systems	
G →	Concrete foundations	
G ↑	Steel foundations	Installation and commissioning
A →	Wind farm construction facilities	
A ↑	Turbine and foundation installation	
A ↑	Subsea cable installation	
G ↑	Civil engineering and construction management	Operations and maintenance
G ↑	Maintenance	
G →	Operations	
G →	Onshore facilities	
G ↑	Transport and Accommodation	
A	RD&D and testing	Professional services

¹ The criteria for the classification are described in Section 3.1.

² Although the traffic light category has not changed, the situation has become more acute. See Section 3.4.1.

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1. Introduction

1.1. The Crown Estate and offshore wind

The Crown Estate owns most of the seabed out to the UK's 12 nautical mile territorial limit, including the rights to explore and utilise the natural resources of the UK continental shelf (excluding oil, gas and coal). The Energy Act 2004 also vests rights in The Crown Estate to license the generation of renewable energy on the continental shelf within the Renewable Energy Zone out to 200 nautical miles.

The Crown Estate has sought to exploit these offshore wind assets through a series of leasing rounds, with a potential total capacity of 49GW. These are summarised in Table 1.1.1.

Table 1.1.1. The Crown Estate's offshore wind leasing rounds.

Round	Year round announced	Original capacity (from public announcements)
Round 1	2000	1.5GW
Round 2	2003	7.2GW
Round 3	2008	32.2GW
Scottish Territorial Waters	2008	6.4GW
Round 1 and 2 extensions ³	2009	1.7GW
Total		49GW

Further rounds are likely to expand significantly the UK's offshore wind capacity looking beyond 2020, with many of these new sites likely to be in deeper water or further from shore.

1.2. Purpose of this study

The UK has the best wind resource in Europe and the development sites and zones represent significant assets for The Crown Estate. In order to help maximise the value of these assets, early in 2009 The Crown Estate

commissioned us to undertake an analysis of the UK offshore wind supply chain, to consider key issues and constraints facing the industry and propose actions to address these where necessary. This study was published online as *Towards Round 3: Building the Offshore Wind Supply Chain* in May 2009.⁴

Much has changed since then. The successful bidders for the Round 3 zones and an additional round of extension projects have been announced and subsequently awarded (as recommended to The Crown Estate as part of our work in 2009). The UK alone has added 750MW of new installed capacity, strengthening its leadership of the global offshore wind market. It is therefore timely to update the analysis. As before, the heart of this study incorporates a significant process of listening to key players in the sector; their aspirations, concerns, and needs, and ideas for addressing challenges.

This study considers all parts of the supply chain, interpreted in the broadest sense to cover not only the components and services needed to install and operate an offshore wind farm but also the infrastructure and broader landscape in which these investments are made.

Although Round 3 zones contain most of the UK offshore wind pipeline, this study also considers the delivery of remaining Round 1 and 2 projects and projects in Scottish Territorial Waters and the rest of Europe. This wider European context is important as, for most key elements of supply, the market of interest is that of the whole of Europe, not just the UK. In addition, in a politically driven sector, the supply chain needs a range of vibrant national offshore wind markets in order to give sufficient confidence and market size to invest.

1.3. Capacity forecast

In order to meet its commitment to the EU target of 20 per cent renewable energy by 2020, the UK will need to generate around 35 per cent of its electricity from renewable sources. The largest contribution will be from wind, both onshore and offshore. Figure 1.3.1 presents our forecast of annual installed offshore wind capacity for the UK, split by region, resulting in a cumulative installed capacity of around 23GW by 2020 with a further 6GW in construction. The forecast is based on our understanding of the status of individual projects and their supply chain and the commercial environment in which the development

³ This excludes enlargements of projects not yet consented announced at the same time.

⁴ *Towards Round 3: Building the Offshore Wind Supply Chain, A review for The Crown Estate on how to improve delivery of UK offshore wind, BVG Associates for The Crown Estate, May 2009.* www.thecrownestate.co.uk/round3_supply_chain_gap_analysis.pdf. Last accessed 24 January 2011.

and supply chain communities are working. We note that the forecast is lower than the aggregate commitments made by developers to The Crown Estate but is higher than some projections by the UK Government linked to the delivery of EU renewable energy targets. Most development is off the east coast of the UK, but with significant capacity installed off Scotland from 2016. We have defined annual installed capacity as the total rated capacity of turbines installed and connected to the grid in that year, and recognise that a single wind farm may be installed over two or more calendar years.

“The UK is, and will remain for the foreseeable future, the largest single market for offshore wind in the world.”

DECC, March 2010

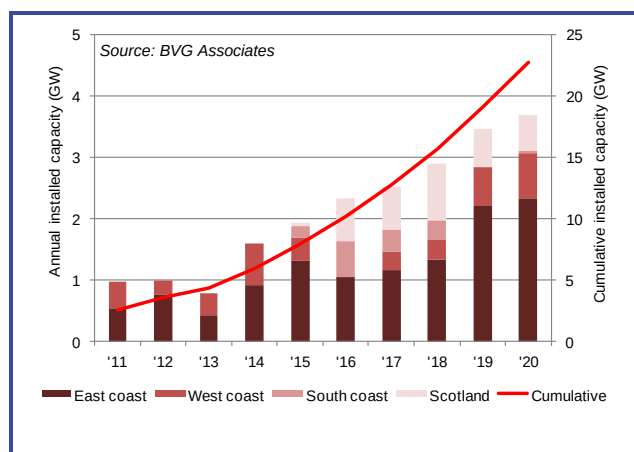


Figure 1.3.1. Forecast annual and cumulative UK offshore installation to 2020.

We believe that the installation of 23GW of offshore wind capacity is the most reasonable and cost effective way of delivering the UK's renewable energy targets based on the status of the portfolio of renewable energy technologies available. It is also considered realistic by many in the supply chain.

We forecast that the power rating of installed turbines will increase relatively slowly from today's average of 3-4MW until 2014, and then will increase more quickly up to an average of around 6MW in 2020. Combining this trend with the installation forecast gives the number of turbines to be installed year by year. This is presented in Figure 1.3.2 which shows around 600 turbines installed annually in UK waters by 2020.

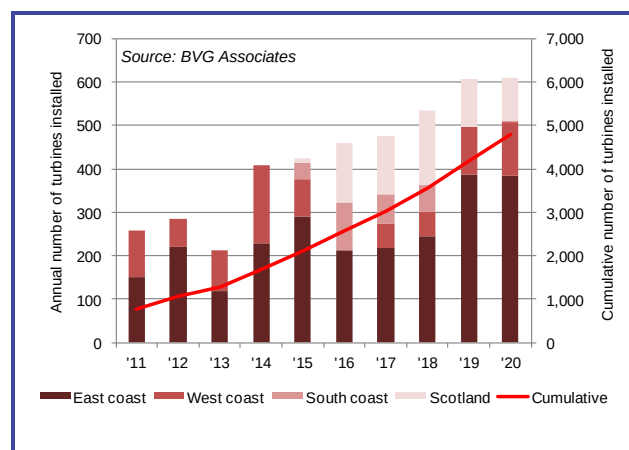


Figure 1.3.2. Forecast annual and cumulative number of UK offshore turbines installed to 2020.

Figure 1.3.3 places our UK forecast in the context of the whole European offshore wind market, with an anticipated total installed capacity of around 50GW in 2020 and a peak installation rate of 7-8GW per year. The forecast of non-UK capacity is based on our understanding of individual projects and projections from industry players, national bodies and the European Wind Energy Association (EWEA). Discussion of the nature and severity of industry and supply chain bottlenecks is based on this European forecast. The cumulative European capacity in 2020 remains similar to what we projected in 2009.

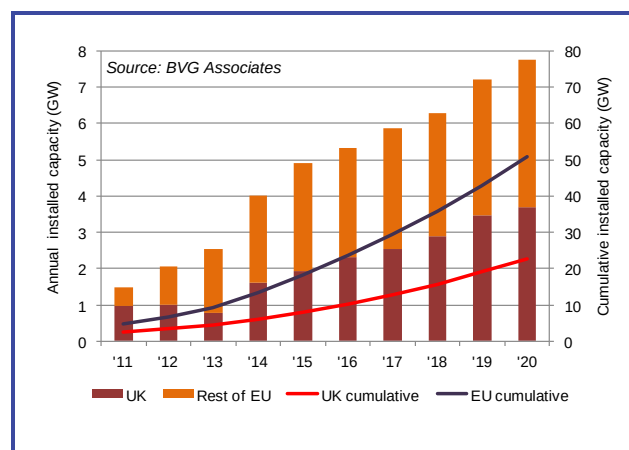


Figure 1.3.3. Forecast annual and cumulative European offshore installation to 2020.

Throughout the report we have presented projections to 2020 as this represents a realistic planning and investment horizon for the industry. It is important to appreciate that this period represents the main growth phase for what we anticipate to be a stable industry, long-term. Figure 1.3.4 shows our forecast extended to 2035, with annual installation levelling off at not that much higher than 2020 levels. We anticipate that the UK will retain around 40 per

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cent of the European offshore wind market for the foreseeable future.

Starting from early in the next decade, we anticipate seeing the first repowering activities, where existing technology is replaced with state-of-the-art next-generation technology. When looking to 2035, from our analysis we expect to have seen towards 20GW of such repowering. Looking further ahead, repowering will become the major source of construction activity. For some elements of the supply chain (such as a blade supplier), the gross cumulative installed capacity is of relevance: that is, the total number of blades supplied, whether or not all are still in operation. For others (such as a maintenance supplier), the net cumulative installed capacity is more important.

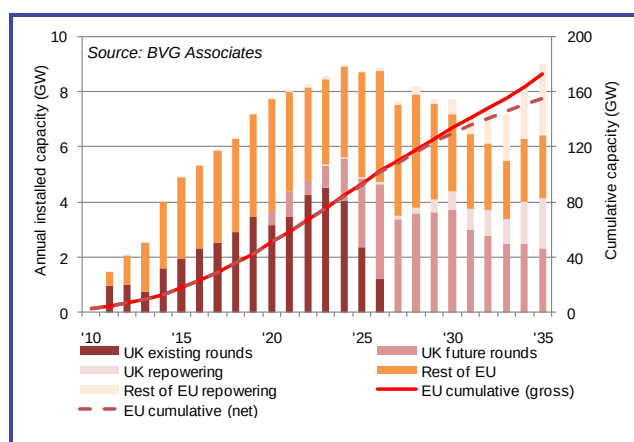


Figure 1.3.4. Forecast annual and cumulative European offshore installation to 2035.

Over the next 10 years, the strategies for the installation of offshore wind farms in Europe are contained in the National Action Plans of member states as each define how they will meet the legally binding renewable energy targets. For the UK, the requirement is to increase renewable energy generation from four per cent in 2010 to 15 per cent of all energy needs by 2020, equating to 30 per cent of the total electricity supply according to the DECC analysis. An aggregate of the National Action Plans for all other EU countries indicates the installation of 27GW of offshore wind capacity by 2020, directly in line with our forecast above.

The drivers for this growth are to decarbonise energy production in the UK, ensure secure and safe energy supplies, and exploit the significant economic opportunities of the move to a low-carbon economy.

“The scale of the offshore wind potential around the UK strengthens the economic, policy and security of supply arguments for working to maximise this offshore renewable potential, and put in place regulatory frameworks to deliver it.”

DECC, July 2010

1.3.1 Industry feedback

In the course of our discussions with developers, we established the status of their projects and captured their views on our aggregate forecast which was generally considered realistic. Generally, developers were confident about the progress they were making on their own projects, though some anticipated slower progress for industry as a whole.

“We would like to get to these levels but we will need a fair wind to get there.”

ROUND 3 DEVELOPER

2. Industry level issues

There are a number of factors that contribute to the successful development of UK offshore wind:

- Government policy;
- Finance and economic viability;
- Electricity transmission;
- Supply chain capability;
- Statutory consultation;
- Health and safety; and
- Skills availability.

While the focus of this study is supply chain capability, insight is also provided in each of the other six areas in the sections below.

2.1. Government policy

Electricity generation is closely linked to the UK's national interest and, while central planning is a thing of the past, the development of any new generating capacity, renewable or otherwise, is influenced by Government policy on climate change, energy security of supply and economic development.

The Government's Renewable Energy Strategy was published in 2009 by the previous administration. Its primary aspiration to increase the UK's renewable energy supply to 15 per cent of consumption is enshrined in legally binding EU targets. The UK's Renewable Energy Action Plan (submitted to the EU by the current administration in June 2010) confirms the strategy's lead scenario, in which a third of the UK's renewable energy supply is provided by wind energy by 2020 and, of this, well over half is offshore.⁵

“Offshore wind will be crucial to delivering our renewable and low carbon targets.”
DECC, July 2010

As did its predecessor, the Government values the economic importance of offshore wind. Wind industry players recognise the value of manufacturing in the market

they are supplying and the anticipated size of the UK market creates a wide range of significant new business opportunities. Siemens Wind Power announced on 20 January 2011 that it had signed a memorandum with Associated British Ports (ABP) to develop new turbine manufacturing and export facilities at the Port of Hull. GE Energy, Gamesa and Mitsubishi have also made commitments to UK manufacture. These businesses have responded positively to public sector investments to develop port infrastructure, including capital grants of £60 million by the UK Government and £70 million by the Scottish Government. This additional investment in Scotland emphasises that, while energy policy has been retained by the UK Government, the devolved administrations are themselves embracing the considerable economic development opportunities from offshore wind. In this respect the Scottish Government has been particularly active and ambitious.

“The UK offshore market is much more attractive - so far.”
STATOIL (FOREWIND)

In England, the Regional Development Agencies have also identified offshore wind as a priority. Several have invested significant resources into inward investment and supply chain development, although much of this was in enabling actions that are yet to facilitate significant job creation. While their abolition may slow this activity, in recognition of the impact of public sector cuts in certain UK regions, the Government has introduced a Regional Growth Fund and it seems likely that this will provide benefits for the offshore wind supply chain.

During 2009 and 2010, the Department of Energy and Climate Change (DECC) used its Environmental Transformation Fund (ETF) to provide around £30 million of support via three funding calls for offshore wind technology demonstration. These served to deepen the UK's relationship with a number of turbine manufacturers including Siemens Wind Power, Vestas, Mitsubishi and Clipper Windpower and to support the investments of ambitious UK-based companies such as JDR Cable Systems (subsea cables), David Brown (gearboxes), BiFab (jacket foundations), Tees Alliance Group (monopile foundations) and Converteam (generators and power electronics). The UK supply chain would certainly benefit from further rounds of such funding.

The Government has also continued to support technology development in the sector via the Energy Technologies Institute (targeting impact towards the end of the decade and beyond), Carbon Trust (short to medium-term impact, that is, three-five years) and also more recently via the Technology Strategy Board. While the UK funding landscape is rather complex, feedback is that the breadth

⁵ *National Renewable Energy Action Plan for the United Kingdom*, Department of Energy and Climate Change, July 2010. www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/ored/uk_action_plan/uk_action_plan.aspx. Last accessed 24 January 2011.

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and depth of UK research, development and demonstration (RD&D) support for offshore wind is well-regarded in other countries.

In general, the industry's view of the Government's commitment to offshore wind is favourable, although there has been some disquiet concerning the time it took to commit ports infrastructure investment. There is also some concern about the potential lack of support for players involved in the UK supply chain who are entering the market in competition with established continental players. This is particularly the case as it is anticipated that the current Government will have a lower focus on direct business support than the previous government. We see that wind industry purchasers and the suppliers themselves recognise their part in building a UK supply chain. They are looking forward to working with Government to maximise the UK benefit of the offshore wind opportunity.

Of greater concern to wind farm developers is recent uncertainty concerning the market incentives for renewable electricity and the regulation of offshore transmission, which impact on the economic viability of offshore wind and introduce risks. These will be discussed in the relevant sections below.

Overall, industry advises that, having signalled a significant acceleration of offshore wind development, of key importance is for Government to provide clarity and continuity of intent. Such intent arches over policy lever changes such as the introduction of a feed in tariff. Along with this, Government is seen to have a role to play in facilitating access to capital markets and raising the confidence of the investment community in what is still quite an immature sector.

Also critical is a strong Government-industry partnership in addressing key issues arising during the development of the market. The establishment last year of a task force to facilitate and accelerate the delivery of offshore wind is seen as a positive step. The Offshore Wind Developers Forum consists of senior executives in the 18 developers working on offshore wind projects around the UK, the Government and The Crown Estate. Currently, it is co-chaired by the Minister of State for Energy and a senior industry figure.

“The purpose of the Developers Forum is to bring together Government and industry to work on solutions to remove barriers that have the potential to impede the viability and deliverability of offshore wind in the UK, and also to try to maximise benefits to the UK economy.”

THE CROWN ESTATE

2.2. Finance and economic viability

2.2.1 Cost of offshore wind

While onshore and offshore turbine costs are comparable (per megawatt), offshore projects incur significant additional capital costs in foundation manufacture, grid infrastructure and installation. Current capital expenditure (CAPEX) for offshore projects is typically more than double that of onshore developments. Likewise, operational expenditure (OPEX) is also significantly higher.

The increase in capital costs of offshore wind projects over the past five years has been considered in some detail, including by RenewableUK in 2009.⁶ Our analysis is that the increases are explainable and an understanding of the drivers is valuable in forecasting future costs. These drivers include market conditions for wind turbines and other key components and materials, exchange rates and physical characteristics of the sites, including water depth, distance to shore and wave climate.

We anticipate that CAPEX is likely to rise to the middle of the decade as tougher sites are developed, then fall marginally as the benefits of new technology outweigh the challenges of later Round 3 sites. OPEX is also likely to drop from the middle of the decade, driven by the benefits of next-generation larger and more reliable turbines. Together with higher mean wind speeds on later sites, the anticipated impact is an improvement in the cost of energy

⁶ *UK Offshore Wind: Charting the Right Course: Scenarios for offshore capital costs for the next five years*, British Wind Energy Association, July 2009.
www.bwea.com/pdf/publications/ChartingtheRightCourse.pdf. Last accessed 24 January 2011.

in the order of 30 per cent in real terms, to be seen most noticeably after the installation of early Round 3 projects.⁷

These improvements are dependent on significant learning and technology development. Measures to help accelerate this progress are discussed below. Even with these improvements, the sector will rely on market incentives for some time yet, so Government policy is a major determinant of the viability of UK offshore wind. This is a concern for utility developers who have to pass these generating costs onto customers in a competitive environment.

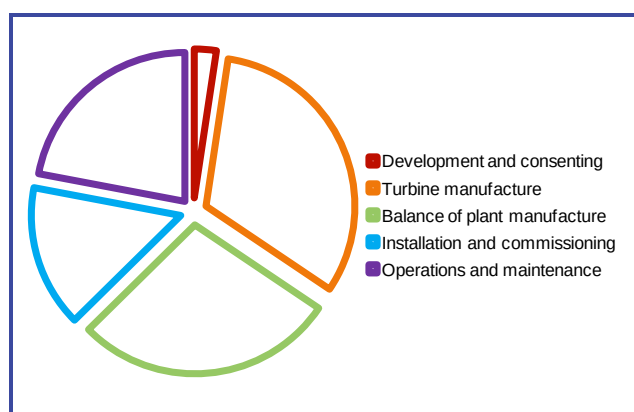


Figure 2.2.1. Breakdown of the cost of energy of European projects to 2020.

2.2.2 Market incentives

The UK's primary industry market incentive to develop renewable electricity generation is the Renewables Obligation (RO). This places an obligation on retailers of electricity to obtain an annually increasing proportion of their electricity from renewable sources. Initially, the scheme was technology blind, seeking to stimulate the deployment of technologies closest to the market. The Government introduced differential banding in 2009, recognising the marginal economics of strategically important technologies. Offshore wind benefited, with projects that receive full RO accreditation between 1 April 2010 and 31 March 2014 being awarded two Renewables Obligation Certificates (ROCs)/MWh. The 2010 Conservative Party manifesto included a commitment to replace the RO with a feed-in tariff (FIT), which has been used with success elsewhere in Europe. On 16 December 2010, the Coalition Government announced a consultation

⁷ Based on a study we are conducting on behalf of RenewableUK scheduled for publication in spring 2011.

on the reform of the electricity market in which the RO would be replaced by a "contract for difference" FIT.⁸

Feedback from developers is that, although FITs reduce electricity price risk, the RO system (due to its longevity) is now well understood and so working well. At a banding multiple of two, most see the UK as the most economically attractive market for offshore wind. This matches KPMG analysis in December 2010 which concluded that the UK's RO provided the most attractive stimulus, followed by Germany, Belgium and the Netherlands.⁹ This is reinforced by the recent ranking given to the UK by Ernst & Young as the most attractive market for offshore wind.¹⁰

"E.ON is neutral about FiTs/ROCs in theory but we are concerned about transition and how the FiT and RO would work together."
E.ON CLIMATE AND RENEWABLES

Developers report significant concern that uncertainty over electricity trading reform and, in particular, the transition arrangements will introduce delays and hamper the ability to attract finance. A delay in market growth of around two years followed the last time a material change was made to the support mechanism, with ongoing investor uncertainty lasting longer still. A further concern to the industry is that replacing the RO removes the increasing obligation on electricity suppliers to source from renewable energy suppliers.

2.2.3 Finance

Two main approaches to financing offshore wind projects have been taken to date:

⁸ *Consultation on Electricity Market Reform*, Department of Energy and Climate Change, December 2010.
www.decc.gov.uk/en/content/cms/consultations/emr/emr.aspx. Last accessed 24 January 2011.

⁹ *Offshore Wind in Europe: 2010 Market Report*, KPMG, December 2010.
www.kpmg.com/Global/en/IssuesAndInsights/ArticlesPublications/Documents/offshore-wind-in-europe.pdf. Last accessed 24 January 2011.

¹⁰ *Renewable Energy Attractiveness Indices*, Issue 27, Ernst and Young, November 2010.
[www.ey.com/Publication/vwLUAssets/Renewable_energy_country_attractiveness_indices_-_Issue_27/\\$File/EY_RECAI_issue_27.pdf](http://www.ey.com/Publication/vwLUAssets/Renewable_energy_country_attractiveness_indices_-_Issue_27/$File/EY_RECAI_issue_27.pdf). Last accessed 24 January 2011.

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- **Balance-sheet funding.** Much of the development by utilities has been funded in this way to date. We believe that these developers are likely to fund around half of the capital investment required for the UK market over the next 10 years on balance sheet, assuming the recycling of capital from projects through partial sale post-construction.
- **Project finance.** The first project-financed wind farm construction activity was the Dutch Princess Amalia (Q7) project in 2006, followed by, phase 1 of the Thornton Bank project.

Some developers have sold equity shares in developments and generating assets to raise funds for new projects. These include RWE, selling the majority of the North Hoyle wind farm, and Centrica, selling a 50 per cent stake in the Lynn and Inner Dowsing wind farm to help finance the Lincs project.

Project finance has been vulnerable to the global economic conditions. According to analysis by KPMG, banks are tending to retreat to more established markets. This has affected German projects in particular, which are more likely to be led by medium-sized developers and hence more likely to need third party finance. We understand from some that the current rates of return available are deemed low compared with alternative opportunities, although we still see progress towards closing significant rounds of funding. Key to improving attractiveness to external funders is reducing risk or improving conditions, especially in the following areas:

- Construction risk, especially of very large projects in new environments. We anticipate that, in the near future, external finance will generally be provided post-construction or with the wind farm developer guaranteeing construction risks.
- Operating risk, where some see returns to offshore transmission network owners (OFTOs) as more attractive than to generation asset owners, which are highly dependent on managing OPEX costs for unproven technology over the long-term.
- Delays between investment and returns. Typically, positive cash flows will not commence until around four years after the financial investment decision. Improvements to the length and certainty of this time period have a strong impact on attractiveness.
- Spreading risk over a portfolio of projects, hence requiring multiple investors on each project. For individual projects of 500MW to 1GW within Round 3 zones, we are likely to see syndicates of eight or more investors involved.

- Exchange rate risk where, typically today, CAPEX is in Euros and revenue in Sterling. As UK content increases, this risk will ease.

Concerns about the availability of finance for renewable energy projects have been widely recognised and there have been initiatives at the UK and EU levels to address any potential market failure. The European Investment Bank has provided finance to a number of offshore wind projects, including Borkum West, Bligh Bank, Gunfleet Sands and London Array. The Green Investment Bank in the UK was taken forward in the June 2010 Budget following an independent commission. It will be set up in September 2012 with a £1 billion fund, some of which may be used to support offshore wind farm construction.

The position of Round 3 developers varies markedly. A number identify finance as a significant concern, considering projects to be too large for balance sheet funding and citing the number of projects scheduled for investment on a similar timeline. Utilities have a portfolio of energy projects also in generation from, for example, nuclear or gas, and offshore wind projects will be considered in this context. There is less concern among developers with a track record in securing external finance, with some confident that offshore wind will be sufficiently attractive for investors. We anticipate that one source of future investment is likely to be China and this may well also be linked to the supply of Chinese technology. We believe there is value in wider dialogue between utility developers and the investment community about likely future needs and conditions for investment. Feedback is that some wind players still recognise a lack of awareness among the financial community about the scale of investment required and increasing maturity of the technology.

2.3. Electricity transmission

2.3.1 UK infrastructure

Industry consultees advise ongoing concern about grid infrastructure as so much design, consenting and site work (and hence elapsed time) is needed to deliver connections within any framework that is finally agreed. We consider issues relating to component supply in Section 3.4.

The concerns relate to the development of the offshore electricity transmission regime. Government and Ofgem have introduced the requirement for OFTOs to separate ownership of the wind farm generating assets from the electricity transmission assets to promote open competition, encourage innovation and bring in new technical expertise and finance. For existing wind farms, this has required the transfer of the transmission asset from the generator to the OFTO (the “transitional regime”) but the arrangement for how the grid infrastructure will be constructed for new wind farms (the “enduring regime”) is

not yet finalised. Ofgem has undertaken a tendering process to identify preferred bidders, who are eligible to bid for specific connections. The OFTO is paid a fixed fee based on its bid for the line by National Grid, which recovers the cost through transmission charges paid by the generator.

Many developers have for some time been concerned that, if the OFTO has the responsibility for constructing the grid connection, they risk developing “stranded assets”, that is, investing considerable sums in a generation assets with nowhere to plug them in. Following further consultation, Ofgem and DECC proposed in August 2010 a “generator build option” which in effect recreates arrangements under the transitional regime that allow the developer to construct then sell on the transmission hardware to the OFTO once complete. Our feedback from the developers is that they favoured this option, although it may be preferred less by the developers of large multiphase zones. We understand that OFTOs would similarly prefer to construct the assets themselves. The financial sector background of some OFTOs may be an advantage in securing finance.

**“We would choose the
“generator build” option - the
more we can bring under our
own control, the happier we are
as a developer.”**

E.ON CLIMATE AND RENEWABLES

A further concern for developers is that they recoup the costs of building the grid connection by selling it on to the OFTO. This represents a significant risk in that the price is fixed externally.

**“OFTO is introducing risk into
the project - project finance
people do not like risk... As
developers we need to de-risk as
much as we can to make each
project attractive.”**

RWE NPOWER RENEWABLES

We have also heard concerns about the OFTO’s incentive to maintain the availability of the grid connection. Wind farm developers are concerned to ensure that risks relating to transmission reliability are properly shared with the OFTO. Today, their view is that the incentive and penalty mechanism to encourage the OFTO to provide a fully operational system seems disproportionately weak compared with the potential loss of revenue suffered by the generation asset owner in the event of a fault.

Earlier concerns about very significant final sums liabilities on wind farm developers seem to have been addressed to a reasonable degree of satisfaction through a number of changes being introduced by the National Grid Energy Transmission.

2.3.2 Transnational infrastructure

A number of subsea interconnectors have been built in recent years. The rationale for this is greater efficiency by allowing a more flexible approach to electricity supply and demand. The concept has been taken further in recent years with the idea of a “supergrid”, a centrally planned high-voltage direct current (HVDC) network connecting key projects and markets in northern Europe and eventually possibly the Mediterranean and north Africa. The initial infrastructure would be based around connecting wind and marine energy sources and the later around photovoltaic technologies. Its supporters argue that it would facilitate the development of sustainable energy and enhance the security of supply as it would enable a higher proportion of renewable energy sources to be managed than would be economic at a national level.

While it is not seen simply as an extension to existing or planned point-to-point connections, it is not inconsistent with the OFTO regime as OFTOs get their income through their supply to the onshore grid rather than via connection charges to the generator. The concept has strong support from a number of Round 3 developers, focused around the “Friends of the Supergrid” campaign, and achieved political momentum in December 2010 when ministers from all 10 North Sea countries signed a Memorandum of Understanding to develop an offshore electricity grid.¹¹

2.4. Supply chain capability

The issues affecting the capability of the supply chain to deliver UK offshore wind farms are the primary focus of this study and in Section 3 a detailed analysis of each area of the supply chain is provided. There are a number of issues that are relevant across the supply chain and these are addressed here.

2.4.1 Market

By the end of 2010, about 3.5GW of offshore wind plant was installed in European waters, which is less than 10 per cent of the total we anticipate will be operational by the end of 2020. The average percentage growth over the next

¹¹ www.eutrio.be/pressrelease/paul-magnette-10-states-sign-north-seas-countries-offshore-grid-initiative. Last accessed 24 January 2011.

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decade required to meet our forecast is no greater than what we have seen onshore over the past 20 years or so. Leaders in the wind industry are used to growth rates like this: past growth has been achieved through activity in a range of markets and with a strong, confident attitude to ongoing investment and growth. Offshore wind relies much more than its onshore counterpart on input from other sectors where such growth rates in some cases have not been the historical norm. This is an important consideration when looking forward at the supply chain.

It is also important to remember that there will be significant supply chain opportunities beyond the wind farms that are currently planned. As long as the industry keeps its position as the renewable energy technology of choice for large-scale generation in northern Europe, opportunities will remain for many decades in construction, operation and eventual repowering of sites with new technology.

In 2009, we found that the level of confidence that has underpinned the growth of the onshore market was not yet present in offshore wind. In this update, we found that, while this confidence has strengthened in some areas, other parts of the supply chain are still holding back investment until firm commitments are received from customers. This investment will be needed if the industry is to deliver the desired generating capacity and make the necessary cost improvements. A strong sentiment from the supply chain is that the anticipated demand presented in Section 1.3 can still be met given reasonable levels of customer commitment and clarity over timescales for construction.

Limited confidence has two effects. First, it limits investment in new capacity, raising concerns about a lack of supply chain capability to deliver. This is especially the case when some elements of the chain hold back due to concerns about supply by other elements. Second, it limits investment in development and demonstration of technologies and processes that will help bring down the lifetime costs of Round 3 projects.

The commitment to manufacture in the UK by four wind turbine manufacturers – Siemens Wind Power, GE Energy, Gamesa and Mitsubishi – in 2010 is a highly significant step in building confidence, enabling for the first time wide-ranging and in-depth discussion between UK suppliers and the wind industry about supply to UK-based assembly facilities. We anticipate more announcements by others in 2011.

Confidence would be further increased if the industry, Government and The Crown Estate shared a common expectation of the installation rate for new offshore wind capacity in UK waters over the next 10 years. To date, The Crown Estate has signed agreements with developers for

the delivery of around 50GW of offshore wind capacity, but there is a disconnect between the potential capacity that could be installed by 2020 and the aggregate expectation of the industry as to what will be installed. The forecast presented here, consistent UK Government's commitment to meet EU renewable energy targets, is for around half of this 50GW to be installed by 2020 with annual installation reaching a rate of around 3.5GW. Some scenarios presented by Government suggest about 14GW cumulative installation by 2020, although we understand that the Government anticipates installation of significantly more than that capacity. Any UK market of 20GW or more by 2020, coupled with a similar order of magnitude activity on the continent, represents a huge opportunity. For much of the supply chain, the cumulative installed capacity is not of much interest as it is the peak annual requirement which dictates the size of manufacturing facilities, for example. Either way, we continue to encourage stakeholders to agree on a common expectation towards which the industry can work together.

Another important way to build confidence within the supply chain is to work with stakeholders in other EU offshore markets to strengthen their frameworks for deployment. A portfolio of long-term sustainable vibrant markets will decrease market risk for players across the sector and assist in increasing competition at all levels.

Several Round 3 development consortia are taking a strategic, proactive approach to supply chain issues, thereby supporting the entry of new suppliers to the market. This is a positive sign. As more players do this the supply base will grow to the ultimate benefit of all projects.

In our earlier report, we found that a positive view of the future of UK offshore wind was not leading to the anticipated levels of engagement from parallel sectors. In industries such as aerospace this is still the case, but the oil and gas industry is now investing in steel fabrication, installation engineering and other services that will make a difference to offshore wind. We need to recognise that, if suppliers diversify from other markets, those sectors may also provide competition for offshore wind supply and its skilled workforce. An example of this is geotechnical vessel supply, where there is sufficient supply to meet the wind industry's demand but availability will depend on the demand from oil and gas companies, for which the charter rates are typically higher.

In the first quarter of 2010, The Crown Estate, in partnership with regional enablers, held a series of supply chain briefings. Attendance was high and, as a first introduction to the sector for many, feedback was that it served its purpose. It was recognised that, at some events, purchaser presence was low. While Round 3 offers the greatest long-term opportunities, for most lower-tier suppliers a greater focus on more near-term activities is

important. A year later, The Crown Estate is running a second series of events, again around the country but this time with more focus on the involvement of tier 1 and 2 suppliers who will be the customers to the UK supply chain, as it grows.

“We need more Tier 1 supply chain players at the events.”
ROUND 3 DEVELOPER

We have also seen some good practice from wind farm developers in increasing the flow of information about their projects that is relevant to the supply chain, for example, by Statoil for Sheringham Shoal.¹² From some enablers, especially the three Regional Development Agencies in the north of England, we have also seen the start of similar activity focusing on gathering technical information relating to upcoming supply opportunities. We advocate a significant increase in the provision of such information that can help suppliers to prepare to bid for business in the sector. This could be even at the level of providing a single overview progress report collating public and non-sensitive information to enable newcomers quickly to establish current status of activities, zone by Round 3 zone.

An early activity of the Offshore Wind Developers Forum (see Section 2.1) is to explore ways of increasing market certainty to incentivise supply chain development and consider how developers could provide information and support further down the supply chain. The Forum has a powerful role to play in growing supply chain confidence and collaboration.

The lack of maturity of the supply chain continues to influence contracting strategies. The multi-contract model that is currently being widely employed seems likely to be favoured for early Round 3 projects, where up to 10 tier 1 packages are contracted with the wind farm developer taking the risk of coordinating these packages. Where companies are taking engineer-procure-construct (EPC) risk, currently it covers narrow vertical sections of the supply chain, such as the turbine foundation. There are clear signs that existing large players and potential newcomers are moving towards bidding for significantly broadened scopes of supply, especially as the supply chain matures and reduces risk to EPC lead contractors. We are also seeing many players progress towards long-term framework agreements rather than repeated open tenders for the supply of hardware and services for individual projects.

“There are further challenges to be overcome if Britain is to maximise its economic benefit. The most important of these will be to attract major turbine manufacturers to base their operations in Britain, unlocking further development of the related supply chain.”
UK GOVERNMENT, JULY 2009

In a young and rapidly growing industry, knowledge and experience are scarce resources. Several developers identified the need to share information as a means of overcoming this issue in a number of areas of the supply chain. This suggests that there is scope to extend collaboration beyond the Offshore Wind Developers Forum discussed in Section 2.1.

“Developers don’t talk - although they are all in it together.”
ROUND 3 DEVELOPER

An option to facilitate sharing would be the creation of a national supplies office. Its role would include enabling a clear time-bound picture of the future opportunities for various elements of the supply chain, connecting suitable suppliers with purchasers, facilitation of sharing of experiences to maximise learning and stimulation of feedback in both directions within the supply chain. In line with this, a number of databases of suppliers have been set up during the past year, in many cases to support regional enabling work. A national, coordinated approach with consistent supply chain categories would facilitate a national-level response to opportunities.

2.4.2 Impact of Round 3

When we last reported in 2009, we were at an early stage in the Round 3 zone award process. A huge increase in the awareness of the opportunities among UK companies followed the announcement of the successful zone developers in January 2010 and the series of supply chain events coordinated by The Crown Estate. The message has been that this major escalation in the deployment of offshore wind, as well as providing a significant focus on new opportunities, brings with it considerable challenges, not only in scale but in operating in deeper waters and further from shore. Developers, especially for the larger zones, have responded to these challenges by forming consortia, enabling them to share risk and experience.

¹² www.scira.co.uk. Last accessed 2 February 2011.

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Different consortia are sharing workloads and responsibilities in different ways.

We see a difference in response of suppliers to the new challenges of Round 3: some would seem to be following a business as usual scenario, seeing Round 3 as merely a larger Round 2; others are embracing the new challenges and thinking strategically about how best to address them.

Round 3 gives UK businesses a significant opportunity to establish themselves in a new, long-term growth sector. We recognise that, for a while, many UK manufacturing businesses have not grown at the rates experienced over the last 20 years in the wind industry. We advocate a partnership between The Crown Estate, Government and industry to develop a vision of what industrialisation for offshore wind could look like in the UK over the next 10 years and what the resulting benefits would be, both in terms of supply to UK projects and export markets. Such job creation will also help to cement offshore wind as a long-term cornerstone of a sustainable energy supply sector in the UK.

UK businesses also have a key role to play in making the decision to engage with, understand and commit to this new sector. One of the key elements in the Government's plans to re-establish manufacturing in the UK is centred on low-carbon technologies. All too often, we hear continental players commenting that UK suppliers are more risk averse than continental partners.

In a number of cases later in this document, we recognise that concern raised by developers about the level of supply bottlenecks reflects as much the perceived risks of contracting new entrants or operating in an environment where there are few competing suppliers as the actual physical limitations of supply.

“UK suppliers should take the advantage of having a home market but we are uncertain if they are dynamic and have the level of ambition of some international companies outside the UK.”

STATOIL (FOREWIND)

2.4.3 Pre-Round 3 projects

In 2009, The Crown Estate invited Round 1 and 2 developers to submit proposals to extend existing projects to increase the capacity before the start of Round 3. The intent was to enable suppliers to invest at the right time to avoid delays in supply chain growth until the start of Round 3 projects. Table 1.1.1 shows that the capacity of the

awarded extensions was 1.7GW. Currently, we understand that at least one of these extension projects is unlikely to go ahead and we are witnessing delays to some Round 2 projects. Humber Gateway, approved in February 2011, is the first offshore wind farm to have been consented since 2008 and a number of projects scheduled to go ahead are slipping, either because they are awaiting consent or are making slow progress towards the construction phase.

The result of these delays to some Round 2 and Scottish Territorial Waters projects and Round 1 and 2 extensions is that the plateau in UK activity in 2012-14 identified in 2009 is now likely to remain, increasing risks to delivery in 2015 and 2016 as the ramp-up to Round 3 starts.

We have found that, in areas such as survey vessel supply, the industry is making do with existing fleets or making interim investments for these projects rather than investing in optimum solutions applicable also for Round 3. The lack of orders for steel fabrications, for example, is also delaying the necessary investment in innovative designs and production processes. However, DECC's ETF offshore wind funding is having a positive impact by supporting selected technology development directly.

We believe that there is value in developers and other potential investors exploring early collective investment in new technology in order to accelerate its impact on their projects. Models for such activity include initiatives by the Carbon Trust and the Energy Technologies Institute, although the focus would need to be on higher technology readiness levels to have significant benefit at this stage.

2.4.4 Technology

Confidence also relates to technology. In our last report, we referred to the issues relating to Vestas V90-3MW turbines that led to a year-long moratorium on sales of this turbine for offshore use. More recently, at Germany's first commercial-scale wind farm, Alpha Ventus, the nacelles of all six Areva turbines were replaced due to an engineering change control quality problem with the gearboxes and others have suffered series failures of key components. We report in Section 3.3.1 the increase in the number of potential offshore wind turbine manufacturers. This will bring a number of new turbine designs onto the market, some from players using gearless drive trains for the first time. There have also been design issues relating to the grouted interface between transition pieces and monopile foundations and also with the long-term integrity of some jacket structures. It is a concern for each member of the supply chain that the industry may not progress as quickly as anticipated due to technical concerns in another area of the supply chain that is outside of their control.

“We are on the edge of a technology transition - offshore wind technologies don’t need to look the same as those onshore, but must perform much better.”

MAINSTREAM RENEWABLE POWER

A widespread sense is that, in some areas such as foundations, foundation auxiliary parts, subsea cables and offshore substations, more standardisation of requirements and designs would enable increased production efficiency. It would in some cases also enable earlier placing for orders for long-lead components with the assurance that these components could be used on a portfolio of upcoming projects rather than only on a single project that might be delayed.

In many areas there remain significant opportunities for further technology development, providing a natural tension with the vision to standardise. We see a real hunger from many within the industry to develop new solutions that will facilitate a long-term trend of lifetime cost reduction.

“We need a more integrated approach - there is a lot of room for more standardisation in the business, for example in foundations and installation methods.”

ROUND 3 DEVELOPER

We also see examples of innovating companies and academics slowed down due to the lack of availability of up-to-date information or by failing to get the attention of potential customers due to the pressures of delivering projects today. A programme giving space for reflection, an ability to focus on the key opportunities for cost improvement, data relevant to today’s challenges (including summary environmental data covering UK Round 3 sites) and the opportunity to grow relationships across sectors could have a significant impact on the progress of technology over the coming years.

We should also increase collaboration in technology development with continental neighbours and organisations in other key countries such as the US and China. In some cases, we see such activity starting to accelerate. In other cases, the UK lags behind in engagement.

The UK should also continue to use its strong RD&D programme to encourage potential inward investors that are of the most strategic importance to establish technology development activities in the UK. A part of this

programme needs to be a range of turbine test sites that meet the range of turbine manufacturers’ requirements. This is discussed further in Section 3.7.1.

2.5. Statutory consultation

Planning consent is required not only for offshore elements of wind farms but also onshore grid connections and any new coastal manufacturing infrastructure. From April 2010, Round 3 wind farms above 100 MW were subject to a single new Infrastructure Planning Commission (IPC) consenting process. While the Coalition Government has pledged to replace the IPC in 2012 with the Major Infrastructure Planning Unit, the process is expected to be retained with the final decision resting with ministers in order to give more democratic accountability to the system. As of January 2011, developers of 12 offshore wind projects have advised the IPC in writing that they intend to submit an application.

The IPC process is broken down into five stages:

- Pre-application consultation;
- Application;
- Acceptance of the application by the IPC;
- Examination of the application; and
- Decision.

According to the IPC, it should take a year to make a decision from accepting an application, though there are concerns that there will be delays during the pre-application phase.

The change to the IPC process, in which issues need to be flagged early, requires a different way of working which is likely to cause some delays as processes settle down. The traditional consenting process has enabled a certain amount of flexibility to be retained while there is uncertainty about the details of a development. The IPC process is founded on the principle that decisions can be speeded up by increasing certainty early. As things stand, there is a danger that consenting can only be progressed by applying “maximum potential adverse effect” or the “Rochdale Envelope”. There needs to be a compromise between developers needing flexibility in order to optimise the wind farm in the detailed design phase and the IPC wanting an early specific project definition.

Developers are concerned about potential delays and quality in the consenting process and the increased risk of delay to projects. This is based on a perception that consultees’ resources are limited because of constrained funding and that applications will be made by developers at

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a similar time and in competition with large infrastructure projects in other sectors.

The recent public spending cuts have heightened concerns that consultees will be unable to deliver responses in the timescales set down by IPC. The issue extends beyond the statutory authorities as our feedback suggests that reduced resources also among non-statutory bodies means that issues are not likely to be raised and addressed at an early stage. We believe that it is critical for the relevant parties to engage in building a common expectation of resource needs among the relevant consultees and addressing any shortfalls. No single organisation currently has responsibility for coordination in order to facilitate the timely evaluation of applications. If one were to take on this role, it could reduce the considerable risk of delay, especially to those projects with more complex consenting issues.

In addition, as projects progress through the consenting phase, we believe it is important that generic issues are proactively addressed and key messages disseminated to other consortia where appropriate.

2.6. Health and safety

The significant increase in offshore operations for Round 3 and the much increased distances from shore raise new health and safety issues. Sadly, we are aware of at least four fatalities associated with UK offshore wind projects, although none are related to working far from shore.

The additional risks from Round 3 have been recognised by The Crown Estate, which has appointed Captain Peter Hodgetts as offshore wind health and safety champion, and RenewableUK, which has set up an offshore wind health and safety group. The industry welcomes these initiatives and the information sharing they facilitate but many recognise that more is needed.

“On health and safety, we need more transparency on good and bad lessons learnt. It’s hard to get a picture of what happened in a project when something went wrong.”

ROUND 3 DEVELOPER

In some cases, we understand that the risks associated with an offshore wind project have been considered separately for each phase rather than for the whole project lifecycle. A more holistic approach would reduce risks, for example, by recognising that the installation vessel choice and capability should influence wind farm design and deployment strategy.

A key issue is that vessels and equipment must be fit for purpose. Continuing to use smaller vessels to work further offshore introduces new risks. It is also important to recognise the onshore risks at ports and substations.

It is recognised that, with an increase in the distance from wind farms to emergency medical care from tens to hundreds of kilometres, changes in protocols and facilities are needed right from the very first activities during offshore wind farm construction in order to protect staff. This may include the early use of fully equipped offshore fixed or floating “hotels” with significant emergency care facilities.

A difficulty is that, while the oil and gas industry has well-developed safety procedures, these do not easily map onto offshore wind. In offshore wind there are a large number of short visits to turbines, each by a small number of people, whereas oil and gas activities typically require lengthy offshore stints with fewer movements of a larger number of personnel at a time. A priority is to learn from other sectors to develop relevant industry-specific practice.

2.7. Skills availability

The offshore wind industry is characterised by its demand for high level skills, at both the professional engineering and technical levels.

“Credible manpower underpins the growth potential of the industry.”

ROUND 3 DEVELOPER

There are various estimates of the number of jobs that will be created in the UK from offshore wind, most notably that by the Carbon Trust in 2008, which placed estimates for new job creation in the range of 40,000-70,000 by 2020.¹³ In 2009, we found widespread recognition of skills issues, prompting RenewableUK to commission two reports on the types and numbers of skilled people needed by the offshore wind industry.

¹³ *Offshore wind power: big challenge, big opportunity - Maximising the environmental, economic and security benefits*, The Carbon Trust, October 2008.

www.carbontrust.co.uk/publications/pages/publicationdetail.aspx?id=CTC743. Last accessed 24 January 2011.

“A good example is the Offshore Wind Technician Training Course - the industry saw a shortcoming, came together and then developed a course and got it accredited by City & Guilds.”
MAINSTREAM RENEWABLE POWER

The demand has prompted collective action to facilitate training provision for offshore wind with a strong emphasis on vocational technical and engineering skills. Notable is the creation of the National Skills Academy for Power (NSAP) under the auspices of Energy and Utility Skills, which provides a national focal point for training provision in the area. A significant issue is that the offshore wind industry's needs extend beyond those of the traditional power sector. Offshore wind needs people with experience of working at sea, for example, so the wind industry needs to play an active role in shaping training provision, largely via RenewableUK.

The Crown Estate recently published a careers guide for young people in partnership with RenewableUK and BVG Associates to stimulate awareness of the range of future job opportunities and the skills requirements of the sector.¹⁴

“If we're to progress to our GW targets for offshore wind with significant UK content, availability of high quality people will become a barrier to delivery.”
MAINSTREAM RENEWABLE POWER

Our dialogue with developers and members of the supply chain confirms the importance of skills as a potential bottleneck, with many reporting a lack of skilled and experienced workers in a range of areas. The issue is not unique to the UK but it is most acute here as a result of the UK's status as the fastest growing market. The international nature of the challenge and the existence of a more developed skills base in wind energy technology on the continent points to developing stronger links between UK and continental trainers (such as at Technical

Universities of Delft and Denmark, both already offering practical skills development in offshore wind construction).

Given the diversity of roles in offshore wind, there is no single solution and we will consider specific issues in each area of the supply chain in Section 3. A difficulty in coordinating provision to close the skills gap is that training cannot be provided too far ahead of need.

A quantitative analysis of the wind industry's skill requirements was published by RenewableUK in February 2011. It found that offshore wind supported 3,100 jobs in the UK in 2010. This data will inform the further analysis needed to shape further initiatives.¹⁵

¹⁴ *Your career in offshore wind energy*, The Crown Estate in partnership with Renewable UK and BVG Associates, November 2010.
www.thecrownestate.co.uk/career_in_offshore_wind_brochure.pdf.
Last accessed 24 January 2011.

¹⁵ *Working for a Green Britain: Employment and Skills in the UK Wind & Marine Industries*, RenewableUK, February 2011.
www.bwea.com/pdf/publications/Working_for_Green_Britain.pdf.
Last accessed 7 February 2011

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3. Wind farm level issues

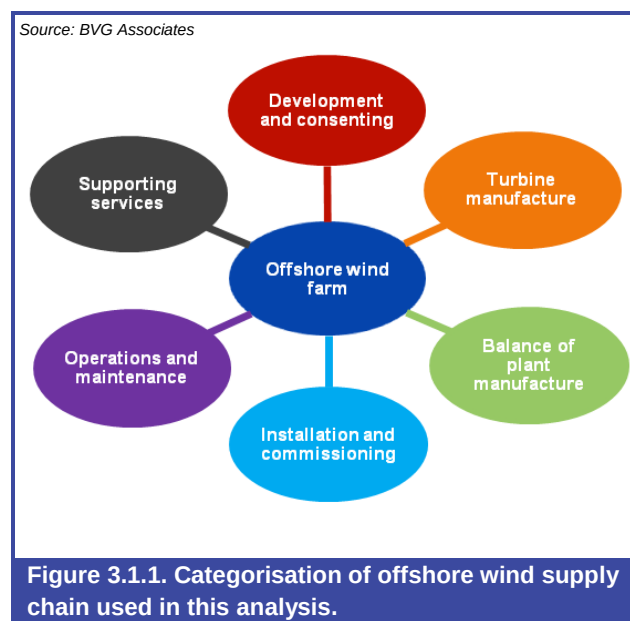
3.1. Approach

This section discusses supply chain issues in six key areas, as shown in Figure 3.1.1. Each section consists of a definition of activities, a summary table and a description of the supply landscape, issues and suggested actions to address these issues. The definitions are:

- G Green.** Not currently an area of concern. Where problems have been identified, there are reasons to believe that these will be rectified by market pressures. A watching brief should be maintained, recognising that significant investment and supply chain development is still required in order to deliver sufficient capacity.
- A Amber.** An area of concern. Some proactive intervention is required in order to address market disconnect.
- R Red.** An area of significant concern. The issue demands further analysis and strategic action.

Our judgement in each case is based on whether an area is likely to constrain delivery in the context of our installation forecast. There will be areas, for example, where the lack of competition or experienced suppliers will give reason for concern, but these do not in themselves constrain delivery. We also indicate how our traffic-light assessment has changed since our previous report in 2009.

In key areas, we have included graphs illustrating the component demand and the associated spend. As an extension to the 2009 work, this data has been offset in time from the wind farm installation forecast to indicate when the component supply will actually be required. For example, for a project installed and grid connected in 2014, typically array cables will be required in 2013.



The areas have been chosen to reflect, as far as possible, discrete activities undertaken by different suppliers. Combined, they cover the bulk of the cost of energy generation from a given wind farm. Further detail is available in *A Guide to an Offshore Wind Farm*, published by The Crown Estate.¹⁶

Development and consenting. The processes up to the point of financial close or placing firm orders to proceed with wind farm construction.

Turbine manufacture. The activity by wind turbine manufacturers and their suppliers: nacelle component manufacture and assembly, blade and tower manufacture.

Balance of plant manufacture. Manufacture of all the components of the wind farm, other than the wind turbine.

Installation and commissioning. This covers all installation and commissioning of balance of plant and turbines, including land and sea-based activity.

Operations and maintenance (O&M). Support during the lifetime operation of the wind farm to ensure optimum output. These activities are undertaken by asset owners or contractors, frequently with a significant role for the wind turbine manufacturer.

Supporting services. Some companies offer services that are relevant to two or more areas of the wind farm,

¹⁶ A Guide to an Offshore Wind Farm, BVG Associates on behalf of The Crown Estate, January 2010. www.thecrownestate.co.uk/guide_to_offshore_windfarm.pdf. Last accessed 24 January 2011.

particularly those in development and consenting, installation and commissioning, and O&M. These include legal, financial and professional consultancy services and RD&D and testing facility provision.

Each of these six areas is broken down into smaller elements in the following sections. In analysing each element, we include significant suppliers in each area category, defining their status as follows:

- **Proven capability.** For example, wind turbine manufacturers that have installed a significant level of offshore capacity, or suppliers with a strong onshore pedigree that is immediately relevant to offshore applications.
- **Likely future capability.** New entrants or players with onshore experience that is not yet sufficient to give high confidence of success offshore.

The lists of suppliers are not intended to be exhaustive and named companies are examples only. It is recognised that, for a study of this sort in a dynamic international sector, there may be omissions or incorrect designations of companies with significant capabilities.

For the purpose of the rest of the analysis, it is assumed that economic, infrastructure and political risks are mitigated, hence delivery depends on issues relating to the physical delivery of wind farms in an environment where the external factors do not impact negatively. The demand is based on the market forecast set out in Figure 1.3.3.

At the beginning of the sections on each of the six areas, we have included a summary table. These will indicate, in our view, whether the supply constraints have changed, for example from a red traffic light to an amber.

Our forecasts of supply, demand and investment presented in graphs throughout this section have been built up using, as far as possible, data on specific projects such as forecast capacity, water depth and distance from shore. This has been used to predict the technologies most likely to be employed. All data is then aggregated, including a project-by-project probabilistic smoothing of installation to reflect uncertainties in projects receiving consent, passing financial investment hurdles and being delivered in line with current time plans.

3.2. Development and consenting

Development and consenting includes all aspects of development services, environmental surveys, coastal process surveys, met station supply, sea bed surveys, front-end engineering and design (FEED) studies and human impact studies. Of these, this section will focus on the following, most significant areas:

- **Environmental impact assessment.** This covers all the activities undertaken to understand and address the environmental impact of the wind farm.
- **Survey vessel operation.** This covers the vessels and associated equipment required to undertake all environmental surveying of the wind farm site.
- **Wind farm design.** This covers the analysis needed to optimise site layout in consideration of capital and operating costs and energy maximisation within environmental constraints and taking into account varying physical characteristics across the site, as well as FEED studies carried out in order to focus procurement activities on chosen technologies and designs.

3.2.1 Environmental impact assessment

Landscape

Establishing the environmental impact of a wind farm is an early focus area for developers, particularly for Round 3 sites given the large areas to cover. As we discussed in Section 2.5, one challenge is to understand the cumulative impacts of large, phased developments within a development zone. The first studies initiated are generally avian, as currently two years of data is required prior to applying for consent.

Issues

Significant early demand. Environmental baseline data needs to be established several years ahead of construction and the infrastructure planning process, described in Section 2.5, requires that the cumulative impacts of a whole zone are described before consent is awarded for an individual project. As all Round 3 zones were awarded at the same time and each development consortium has an early focus on environmental surveying, we are seeing an early demand for which there is little time to address any supply shortage. There is however significant expertise among existing suppliers and consultancies from other sectors, so although we expect pressure on key players, we do not foresee bottlenecks that will impact project timescales significantly.

3.2.2 Wind farm design

Landscape

Different elements of wind farm design are undertaken by specialist consultancies and in-house by those developers with sufficient experience. As the understanding of offshore conditions and technologies develops and the size and complexity of projects increase, the opportunities for optimisation also grow. We anticipate the development of new processes in this space over the next 10 years.

DEVELOPMENT AND CONSENTING						
Proven capability (examples only)	ABPmer, Aecom, EMU, Entec, ERM, Natural Power, PMSS, Royal Haskoning, RPS, RSK	Aecom, GL Garrad Hassan, GL Noble Denton, Kema, Metoc, Mott MacDonald, ODE, PMSS, RES, SKM, TNEI, Wood Group Developers' in house capability Component-specific designers (e.g. foundations)	EMU, Fugro Seacore, Gardline, GEMS, GEO			
Likely future capability (examples only)	WSP	Arup, Frazer Nash, Atkins	Calegeo, MMT			
Environmental impact assessment				Wind farm design		
Market Concentration	Low		Low	Medium		
Issues	Significant early demand.		Early demand with limited number of experienced suppliers.	- Requirement for new larger vessels. - Shortage of suitable geotechnical vessels. - Shortage of specialist skills.		
Actions			- Maximise sharing of experience and learning. - Accelerate introduction of new suppliers and optimisation tools.	- Be flexible in use of vessels. - Bring through more efficient technology.		
Traffic light rating (see Section 3.1)	2011	Was	2011	Was	2011	Was
		n/a		n/a		n/a

Issues

Early demand with limited number of experienced suppliers. There are a number of suppliers in the market and many competent players from parallel sectors, but their ability to meet anticipated demand is limited by the need to recruit or retrain suitably qualified staff with offshore experience. We see that the situation is particularly acute with electrical high voltage (HV) engineers. In a young and rapidly growing sector it is inevitable that there is a shortfall of experienced personnel and it will be necessary to recruit and train from parallel sectors. Some developers have sought to grow in-house teams to manage this risk and retain lessons learned from previous projects. Again, we recognise that more experienced teams are likely to design wind farm layouts and key balance of plant items with a lower lifetime cost, but we anticipate sufficient sharing of information so that any shortfalls will not have a significant impact.

Actions

Maximise sharing of experience and learning. The need for improved dissemination could be addressed through focussed events organised by either commercial conference providers or enablers. Dialogue should not solely take place between UK players.

Accelerate introduction of new suppliers and optimisation tools. Raise awareness of technical challenges and opportunities for new players from parallel sectors, especially in the development of new tools to facilitate multi-variable optimisation of wind farm layout.

3.2.3 Survey vessel operation

Landscape

Survey vessels are needed to capture data to inform environmental impact assessments and wind farm design decisions. Developers commission surveys of flora and fauna and sea bed conditions. A number of companies have gained near shore experience through providing such services for Round 1 and 2 projects.

“A number of developers have been trying to do the same work in the same season which has meant a shortage of vessels.”
RWE NPOWER RENEWABLES

As in many areas of the supply chain, the industry's transition from Rounds 1 and 2 to Round 3 is significant. The zone approach of Round 3 means that initial surveys are needed to capture the data to determine the optimal areas for development as well as potential cumulative impact. Generally, this work began in the second half of 2010. Having decided upon the areas and phasing of

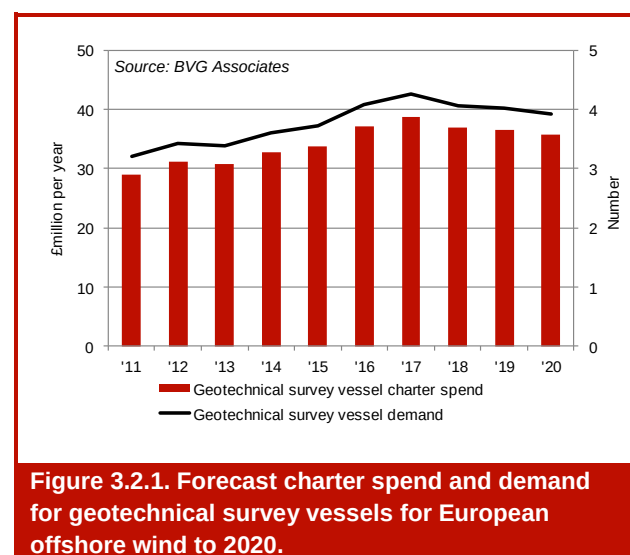
development, more detailed and project-specific work will be undertaken.

Issues

Requirement for new larger vessels. Much of the survey work for Rounds 1 and 2 used vessels of convenience, but much of Round 3 will not allow such flexibility. Some of the companies that have a background in coastal surveying have vessels that are not suitable for Round 3 surveys. The general requirement is for larger vessels that can remain at sea for weeks in challenging weather conditions. Geophysical and geotechnical surveys in particular require specialist equipment operating from vessels with specific characteristics.

“People often use vessels that are there and available rather than most suitable.”
ROUND 3 DEVELOPER

Shortage of suitable geotechnical vessels. Some developers report a lack of survey vessels reflecting the transition in requirements from Rounds 1 and 2. The problem was considered most pressing with geotechnical vessels. Figure 3.2.1 shows the demand for such vessels, assuming that a combination of core sampling and cone penetration tests are used. It indicates that the peak demand will be about four fully mobilised offshore geotechnical vessels.



We understand that there are currently nine geotechnical vessels suitable for Round 3 being operated by companies with a track record in offshore wind. These are not exclusively used by the offshore wind sector and there is ongoing demand from the oil and gas sector, but in terms of capacity we do not see a significant shortage.

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The oil and gas sector, with higher margins, is able to pay higher day rates for geotechnical vessels. Developers may struggle to find affordable vessels if they are unable to be flexible over the timing of the work within a given year.

Shortage of specialist skills. In line with many technical professions, there is a shortage of offshore geotechnical engineers.

Actions

Be flexible in use of vessels. By engaging with vessel suppliers and tolerating flexibility over timing, we anticipate that developers will be able to charter suitable geotechnical vessels.

Bring through more efficient technology. Technologies exist that can speed up and improve the quality of information gathered. As well as decreasing costs, the use of such technology will reduce the demands on vessels.

3.3. Turbine manufacture

Turbine manufacture involves the supply of all electrical and mechanical components and systems that make up a wind turbine housed within the nacelle, rotor and tower. The nacelle components typically include the nacelle bedplate, main bearing, main shaft, gearbox, generator, power take-off, control system, yaw system, yaw bearing, nacelle auxiliary systems, nacelle cover, fasteners and conditioning monitoring system. The rotor components include the blades, hub casting, blade bearings, pitch system, spinner, rotor auxiliary systems, fabricated steel components and fasteners. The tower components generally include steel, personnel access and survival equipment, tuned damper, electrical system, tower internal lighting and fasteners. Though many components play an important role in the long-term reliable operation of the wind turbine, we see that, for most designs of wind turbines and with careful procurement planning, none of these items present a significant potential bottleneck in the next few years. Of the turbine components, this section will focus on the following, most significant areas:

Offshore wind turbines. Complete supply, including all of the items below.

Blades. Blades form a significant element of the turbine cost (around 20 per cent). Almost all blades for offshore wind turbines are currently manufactured in-house by wind turbine suppliers. As the final assembly of blades to the turbine only happens close to the site and the transport of blades is a significant consideration, it is relevant to consider blade manufacture as distinct from turbine nacelle assembly and other main component manufacture: it can be carried out efficiently at a separate coastal location.

Castings and forgings. These items include the hub, main shaft (where used), main frame (in some cases), gearbox

casings (where used) and bearing forged rings. For very large offshore turbines, minimising transport of these items will start to become an important consideration.

Gearboxes, large bearings and direct drive generators.

All offshore turbines in the market today use gearboxes. Siemens Wind Power, GE Energy and a number of other significant players plan to introduce direct drive (gearless) offshore turbines. Areva uses a low-ratio gearbox and mid-speed generator, again a trend we expect to be repeated by others. Vestas and REpower both use gearboxes and high-speed generators. Bearings are critical supply items for incorporation into the gearbox as well into nacelle and hub sub-assemblies.

Towers. As for blades, towers need not meet other turbine components until they reach the offshore site, so they can be sourced separately from turbine nacelles. Again, logistics become critical for very large offshore designs, requiring a move to coastal manufacture. In some onshore markets, towers have been procured by the developer (to the turbine manufacturer's design), but the pattern offshore currently remains for the wind turbine manufacturer to source supply against their own design.

3.3.1 Offshore wind turbines

Landscape

The anticipated number of offshore turbines required in Europe and the associated spend is presented in Figure 3.3.1. It is based on an average turbine size installed increasing to just under 6MW in 2020. The notable increase in turbine numbers in 2014 reflects the fact demand at this point will be met mostly from existing sub-5MW machines, with many next generation models yet to be established in the market.

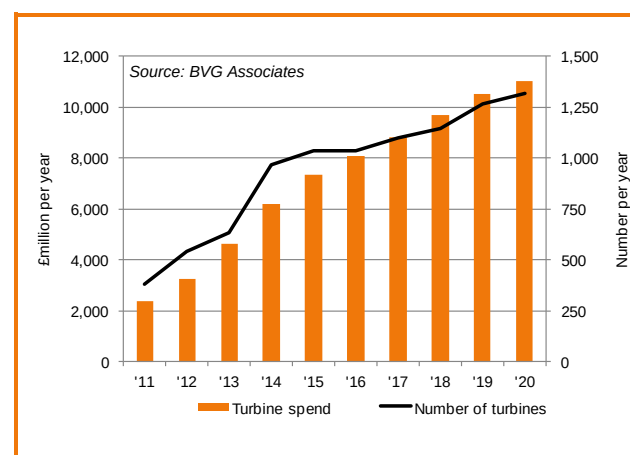


Figure 3.3.1. Forecast spend and demand for offshore turbines for European offshore wind to 2020.

TURBINE MANUFACTURE

Proven capability (examples only)	REpower Siemens Vestas	LM Wind Power Siemens Vestas	Castings Eisengießerei Torgelow, Felguera Melt, Fonderia Vigevanese, Metso, Meuselwitz Guss, Rolls Royce, Sakana, Siempelkamp, Vestas Forgings Brück, Euskal, Skoda, Thyssen	Gearboxes Bosch Rexroth, Hansen (Suzlon), Moventas, Renk, Winergy (Siemens) Large Bearings FAG, IMO, Liebherr, NSK, NTN, Rollix, Rothe Erde, SKF, Timken Direct drive generators Converteam, Siemens, The Switch	Ambau, BiFab, Bladt, DSSM, SIAG, Skykon, Vestas
Likely future capability (examples only)	Areva, Bard, Clipper, Gamesa, GE Energy, Goldwind, Mitsubishi, Nordex, Samsung, Sinovel, XEMC	Powerblades (REpower), PN Rotor (Areva). Various wind turbine manufacturers with in- house capability	Various UK players and non-EU players	ABB, David Brown, various non-EU players	Mabey Bridge, TAG
Offshore wind turbines Blades Castings and forgings Gearboxes, large bearings and direct drive generators Towers					
Market concentration	High	High	Medium	High	Medium
Issues	- Lack of proven turbines. - Significant technical development still needed. - Lack of coastal turbine assembly and large component manufacture.	- Need for new coastal facilities. - Little independent competition. - Much technology development is needed. - Need for more test rigs for large blades.	- Limited supply of castings, especially at larger sizes. - Lack of UK supply.	- Limited supply, especially at larger sizes. - Poor operational reliability. - Security of supply of permanent magnets.	Need for new coastal facilities.
Actions	- Invest in coastal manufacturing facilities. - Continue RD&D support with focus on verification of new products. - Accelerate delivery of reliable technology.		Support development of optimally located UK supply.	- Focus on improving reliability. - Grow the supply chain in direct drive generators. - Focus RD&D on reducing the requirements for naturally occurring rare earth materials.	
Traffic light rating (see Section 3.1)	2011	2011	2011	2011	2011
	Was	Was	Was	Was	Was
					

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In 2009 we found that wind turbines were the critical supply item for most developers due to the lack of competition in the offshore market and the significant focus of players that were present on the technical and supply chain challenges of onshore wind. Two years later, Siemens Wind Power and Vestas continue to dominate the market (see Figure 3.3.2). REpower will commence operation on its first commercial scale wind farm in the UK in 2011 and Bard continues to make progress in building a track record supplying to wind farms that it is developing in Germany and the Netherlands.

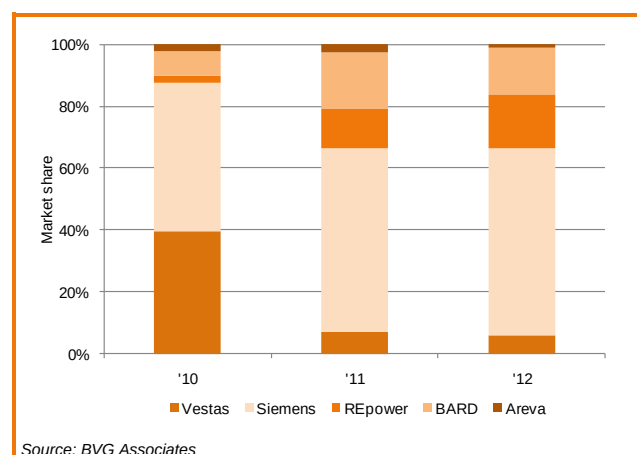


Figure 3.3.2. Current and forecast share of European offshore wind turbine market (known projects only).

In the past, this lack of choice has concerned developers but REpower, BARD and Sinovel will achieve a pedigree of 200 MW offshore capacity in 2011, and Areva will follow shortly afterwards. The increased focus of existing players and public commitments from a number of major manufacturers such as GE Energy, Alstom, Gamesa, Mitsubishi and Nordex to move into the offshore market mean that post-2015 the offshore turbine supply market is likely to become properly competitive. Indeed, at the last count we are aware of over 25 credible wind turbine manufacturers that are developing technology in preparation for sales in offshore wind in the EU. The number of potential turbine suppliers today is far more than we anticipated in 2009 and the dominant reason why we believe this supply chain constraint has eased since then.

“Compared with 18 months ago there are more players entering in the market which is good - it will not be a long term bottleneck.”

ROUND 3 DEVELOPER

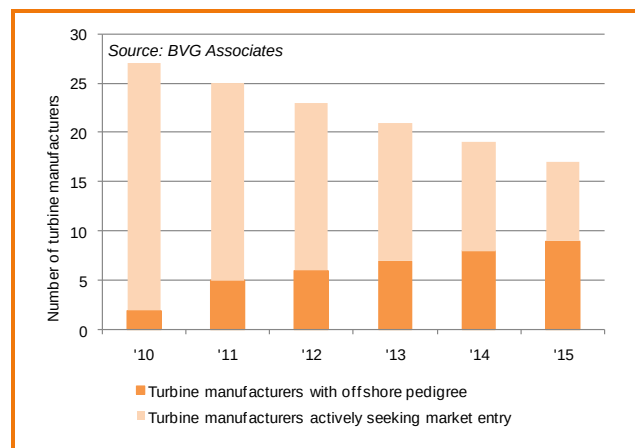


Figure 3.3.3. Forecast number of turbine manufacturers globally seeking offshore market entry and with offshore pedigree.

Many of these manufacturers will not secure the necessary investment or make a significant impact on the market. The onshore market sustains a large number of manufacturers but the European offshore market may not be viable for more than 10 players in the long term. The market is likely to remain smaller than the onshore market and projects will be larger, at a minimum size of around 400MW, making it difficult for smaller players to gain a foothold. Figure 3.3.3 shows our forecast of the number of wind turbine manufacturers with offshore pedigree or who are hoping to enter the market up to 2015, with pedigree being defined as having 200MW turbines operating offshore in Europe, China, the US or elsewhere.

New technology

The growth of turbine size (rated MW capacity) in the European onshore market continues to increase but few series-produced onshore turbines have a rating over 3.5MW due to transport and other physical constraints. Existing suppliers of offshore turbines generally expect that variants of today's turbines will remain core products dominating sales into 2013/14, with next-generation, larger technology only taking over from 2015. This means that, for some time, the market will be dominated by technology adapted for offshore use, rather than technology that has been designed fundamentally for offshore use. Effort will continue to be put in to improve both reliability and maintainability but significant strides in terms of the lifetime cost of energy improvement are likely to come only with next generation products designed solely for offshore use.

The driver for increased turbine size is reductions in the cost of energy. This is mainly due to increased capacity factors from taller towers and larger rotors relative to rated power, lower overall wind farm CAPEX cost per MW, and lower OPEX costs, which stem primarily from the reduced

total number of units required for a given wind farm capacity.

The largest turbine available to the market today is the 6.15MW REpower 6M. Within the time frame being considered in this study, we believe that the average turbine size in European projects will rise to this sort of size by 2020, with the largest likely to be 10MW. Clipper and American Superconductor and others are developing 10MW machines.

There are no signs that the growth in offshore turbine size is slowing. Indeed a consortium of Spanish companies, including Gamesa, Iberdrola and Acciona has embarked on a project at 15MW scale.

Much learning can be derived from the existing UK and European experience of constructing and operating offshore wind farms. More feedback into the design of both turbine concepts and individual components and sub-systems is required. The lack of accessible relevant operational and reliability data is also limiting the effectiveness of innovators, especially those from outside of the wind industry.

In addition to the requirement to improve the reliability of offshore turbines, the removal of some of the constraints affecting onshore wind, especially in northern Europe, provides a significant opportunity for innovation in offshore technology. Unlike for onshore wind, there are also fewer barriers to increasing turbine size. In response, we are seeing a reconsideration of design concepts, including a return to the development of two-bladed turbines and vertical axis turbines, both with potential technical advantages at the largest scale which are not likely to be seen onshore, though likewise may not be seen offshore for another decade.

Issues

Lack of proven turbines. Despite Siemens Wind Power, Vestas and others developing new turbine technologies for the offshore market, there will be few proven turbines on the market as the first supply contracts are signed for Round 3 in 2013/14 and there remains a concern that there may be short-term turbine supply constraints. The next generation of offshore turbines will be designed specifically for the offshore environment and most will be rated at around 6MW. The expectation is that, for projects further from shore and in deeper water, these turbines will offer significant reductions in the cost of energy compared with the mainly marinised onshore turbines used to date. This is mainly due to reduced balance of plant and OPEX costs, rather than lower turbine costs. However, until they have been tested, this is unproven and developers will face the challenge of whether to adopt newer technology with the potential for lower cost energy or stay with better known

risk technology. The issue of RD&D and test facilities is addressed in Section 3.7.1.

Significant technical development still needed. Activity is required at the concept and component levels, both by wind turbine manufacturers and key members of their supply chain. The limited resources in the technology departments at turbine manufacturers have for some time been focused on onshore issues rather than offshore. As competition for offshore market shares increase, we expect this balance to change for the players committed to succeed in the sector.

Lack of coastal turbine assembly and large component manufacture. Today, few turbines are being assembled at locations with direct access to coastal load-out facilities. The same is true for blades and towers. Siemens Wind Power, GE Energy, Gamesa and Mitsubishi have committed themselves to UK manufacture and new coastal assembly and manufacturing sites are needed for these and other players looking to capture a significant market share. Such facilities will need to be consented and constructed before the anticipated ramp-up in demand.

Actions

Invest in coastal manufacturing facilities. While a number of locations have been identified, significant development will be required at most sites in order to facilitate efficient logistics for manufacture and dispatch of the next generation of wind turbines. The Government's commitment to support this is welcome, though it is anticipated that more public and private funding will be required to facilitate development on the scale needed.

Continue RD&D support with focus on verification of new products. This should include the development of onshore and offshore test sites and accelerated use of workshop testing to speed up the verification of new technology. While a good number of developers have expressed concern at the lack of proven turbines, few have sought to facilitate the development of offshore or onshore test sites to speed up the required verification.

Accelerate delivery of reliable technology. A key specific area of focus in bringing forward new technology needs to be increased reliability. This could be through the improved sharing of reliability data and the extension of existing third party type certification to consider reliability. A trend towards more demanding availability guarantees would further drive technological development in this area.

3.3.2 Blades

Landscape

Around 60 per cent of blades are manufactured in-house by turbine manufacturers and this fraction is higher still for offshore wind. There are also a growing number of

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independent blade manufacturers, though only market leader LM Wind Power has started to build significant experience with the largest of blades for offshore wind. There are no indications or expressed concerns that supply will constrain the delivery of offshore wind.

Issues

Need for new coastal facilities. The transport of offshore blades on land is expensive and manufacturers will need coastal sites for future blade manufacturing, ideally alongside nacelle assembly facilities.

Little independent competition. LM Wind Power currently dominates independent blade supply. There are a number of potential new entrants but the entry hurdles are high.

Much technology development is needed. In order to meet the requirements of increased quality and decrease capital and operating costs at significantly increased sizes, there is much room for process and materials development. In addition, work on new methods of aerodynamic control will become more attractive as blade size increases.

Need for more test rigs for large blades. With a number of manufacturers introducing new products for Round 3, new large-scale facilities will be required.

3.3.3 Castings and forgings

Landscape

Spheroid Graphite (SG) iron castings are used for following components:

- Hub;
- Nacelle bedplate (some suppliers; others use steel fabrications);
- Main bearing housing (if present); and
- Gearbox housings and support components (if present).

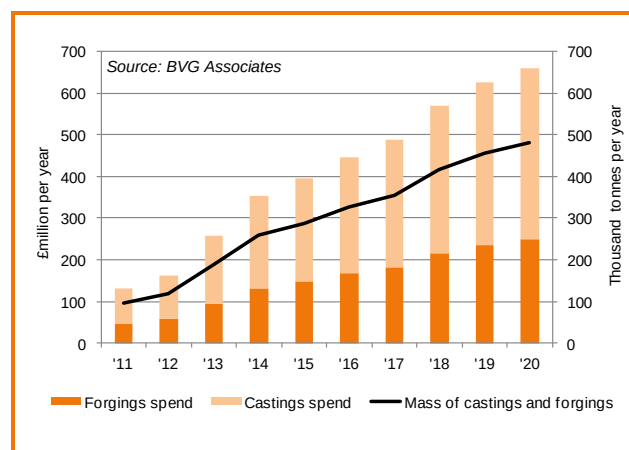


Figure 3.3.4. Forecast spend and demand for castings and forgings for European offshore wind to 2020.

These castings are normally produced by large foundries which serve customers in many different industries. In order to secure their supply chain, wind turbine manufacturers have generally entered into long-term framework agreements and, in some cases, have acquired suppliers or established their own facilities in order to be able to in-source components. The wind industry is expected to consume 50 per cent of the estimated total global capacity of established suppliers of suitably sized castings by 2012. Recent tightness in supply is easing as existing players expand their capacity and new companies enter the market, especially in India, China and the US.

Steel forgings have greater strength and ductility than cast iron. They are used in the following components:

- Bearings – both slewing rings (blade and yaw bearings), and main shaft and gearbox bearings;
- Shafts;
- Gear wheels; and
- Tower section flanges.

The anticipated demand and spend profile for castings and forgings for European offshore wind is shown in Figure 3.3.4. This is based on a usage of approximately 30 tonnes of castings and 15 tonnes of forgings per MW for 5MW-scale turbines (less for smaller turbines) to match current industry usage patterns.

Issues

Limited supply of castings, especially at larger sizes.

The supply of castings over 20 tonnes for offshore wind in significant quantities manufactured close to the point of use is insufficient to meet the anticipated demand. With an increase in supply of castings from Asia, European players

may be encouraged to concentrate on new offshore supply, but not many are well-located for this at present.

Lack of UK supply. Feedback from some turbine manufacturers is that the assembly of turbines in a given market will follow the supply of key components from that market. One key set of components are the large castings and forgings, which are especially critical because of the high transport costs. Other turbine manufacturers expect their existing supply chain to follow to new manufacturing locations, so the availability of relevant skills is more of a need than the existing established suppliers. The UK has in the past manufactured very large iron castings and mid-quality steel forgings and still has some strong relevant skills. There is now interest in re-establishing such facilities, which will increase the attractiveness of UK investment by turbine manufacturers.

Actions

Support development of optimally located UK supply. Given the strategic importance of the UK turbine supply to the delivery of Round 3, we advocate the support of UK suppliers to enable them to compete with continental suppliers. Any development of metal forming needs to be coupled with value-adding activities such as machining and painting to provide a joined-up, low-logistics solution using the latest technologies.

3.3.4 Gearboxes, large bearings and direct drive generators

Landscape

The supply of gearboxes for the wind industry has been an area of concern for some time. Again, investment in new capacity has been significant and European supply is currently more than sufficient to meet demand for typical gearboxes for onshore use, though the market is more balanced for larger gearboxes for offshore use.

Gearbox failures have been high profile and, although faults occur less frequently than for many other turbine components, any main drive train component failure requires significant external intervention. Technical trends have focused on reducing the number of drive train components and driving up reliability through holistic system design and thorough verification.

Large bearings have also been an area of concern, including gearbox, generator and main shaft bearings in the nacelle and blade bearings. The constraint arises from the small number of companies capable of supplying these large bearings. The recent tightness of gearbox supply was mainly attributed to bearing supply issues, which in turn are significantly affected by the availability of high-quality steel forgings.

There is a considerable amount of work underway to improve bearing lifetime, especially with respect to steel quality, the optimisation of bearing internal geometry and the development of oils and greases that protect bearings over the whole range of conditions seen during a wind turbine's lifetime. For generator bearings, work continues to improve to minimise the impact of local electrical effects on bearings.

A significant new trend since we last reported in 2009 is the planned increase in the use of permanent magnets in generators, primarily for direct drive models, which can contain over several tonnes of magnetic material. Permanent magnets are formed from rare earth elements. While these are found worldwide, productive mines are currently almost exclusively in China.

Key reasons for the tightness of supply include:

- A large increase in demand in the wind industry coupled with demand in other industries (for example, mining and ship building);
- High entry barriers including industry-specific know-how to provide a reliable product;
- The high cost of production and test hardware;
- Constraints on supply of key components, including specialist steels and large castings and forgings; and
- Constraints on the supply of permanent magnet materials, used in larger quantities high-torque, for direct drive generators than in more conventional high-speed applications.

“There is an issue with permanent magnets and speculation about whether there is enough, although turbine manufacturers pretend they have secured the supply.”
ROUND 3 DEVELOPER

A significant addition to the UK's capability to lead future drive train development is the investment in a new test rig at Narec at Blyth in north east England. Funded by the Energy Technologies Institute and One North East, it will be the world's largest open access offshore wind turbine drive train test rig. It will be able to test a complete wind turbine drive train with input power up to 15MW.

While there is an issue about permanent magnet supply, as we will discuss below, overall we believe that the supply

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chain constraints for wind turbine drive train components have eased since 2009.

Issues

Limited supply, especially at larger sizes. There has been a significant expansion of supply capability for gearboxes and large bearings in recent years, both from established players and newcomers to wind that are located within key growth markets, especially China and the US. So far, these newcomers have generally not supplied the offshore market where the risks are greatest and the components are at the largest end of the ranges supplied. This situation is now changing, increasing the competition in this higher-risk sector, with highly experienced player David Brown Gear Systems entering the gearbox market in the UK, for example.

Poor operational reliability. Gearbox reliability has been a key issue for the wind industry for many years. High-profile problems with Vestas's offshore V80-2MW and V90-3MW turbines have raised significant concerns, especially due to the high costs of replacement. The considerable focus of engineering time in this space, especially by the more established players, seems to be paying off and there is no certainty that direct drive concepts with fewer moving parts will be substantially more reliable: the reliability of both concepts relies on excellence in holistic design of the whole drive train system.

Security of supply of permanent magnets. Permanent magnets are formed from rare earth elements. Of these, neodymium is the most commonly used in permanent magnetic generators (PMGs). China holds around 50 per cent of global deposits but provides about 97 per cent of the current global supply, following the closure of mines elsewhere in the 1990s on economic grounds. China's Government has imposed production quotas, prompting concerns about the security of supply to turbine manufacturers.

Increased demand has reversed this trend of mine closures outside China. According to the US Department of Energy's Critical Materials Strategy, 2010 production of neodymium oxide was 21,000 tonnes. It forecasts that new supplies, mainly from Australia and the US, could provide a further 9,000 tonnes by 2015¹⁷. Assuming that 20 per cent of European offshore turbines are using direct drive PMGs by then, we forecast that this will use only 0.2 per cent of global neodymium oxide supply. Even if 60 per cent of turbines are using direct drive PMGs in 2020 and global

supply remains constant from 2015, this figure will rise to only 2.4 per cent.

Costs could remain volatile as the current situation of the limited geographical spread of supply evolves into increased competition in the second half of the decade as European offshore wind competes with the onshore wind sector and the electric vehicle market for supply, but we do not believe it will constrain deployment. Towards the end of the decade, it is anticipated that the early application of high temperature superconductor technology and other developments with permanent magnet materials will start to reduce the reliance on rare earth materials.

Our feedback from developers is that turbine manufacturers have already sought to provide reassurance about the security of material supply. In order to mitigate risks, we expect that some players will seek to locate component manufacturing facilities in China in case of locally imposed value-add requirements.

Actions

Focus on improving reliability. The recent focus on reliability by many in the offshore wind market needs to be further extended, incorporating learning from parallel sectors such as aerospace, the development of more advanced condition monitoring systems and more thorough design and verification programmes for drive train components and the integrated system.

Grow the supply chain in direct drive generators. With the projected increase in the use of direct drive permanent magnet generators, a new area of supply needs to develop quite rapidly. Special care will be required in order to meet quality cost and delivery requirements if the sector is to avoid many of the "growing pains" seen with new technologies in the past.

Focus RD&D on reducing the requirements for naturally occurring rare earth materials. Manufacturers will seek to reduce their reliance on permanent magnets. For example, GE has been awarded a \$2.2 million US Department of Energy research grant to develop bulk nanostructured magnetic materials, which aims to reduce the use of rare earth elements by 80 per cent.¹⁸ UK investment in this area could form part of the UK's inward investment strategy.

¹⁷ *Critical Materials Strategy*, US Department for Energy, December 2010. www.energy.gov/criticalmaterialsstrategy. Last accessed 24 January 2011.

¹⁸ <http://arpa-e.energy.gov/Media/News/tabid/83/vw/1/ItemID/23/Default.aspx>. Last accessed 24 January 2011.

3.3.5 Towers

Landscape

There are a number of independent suppliers of wind turbine towers and some turbine manufacturers also have in-house capacity. New capacity will be needed for offshore wind but the barriers to entry are relatively low and lead times shorter than for many other components. The UK has an established tower manufacturing facility in the west of Scotland and Mabey Bridge is commissioning a new tower facility in South Wales, although this will be focussed on supply to the onshore market in the first instance. Towers are usually procured by the turbine manufacturer but this may change, particularly if there are trends towards an integrated tower and foundation design for offshore wind.

Issues

Need for new coastal facilities. There are strong logistical reasons for locating tower manufacture alongside quayside nacelle assembly as towers will be installed from the same vessel.

3.4. Balance of plant manufacture

Balance of plant includes all aspects of cables, turbine foundations, and offshore and onshore substations. Of these, this section will focus on the following, most significant areas:

Subsea cables. Export cables connect offshore substations to shore. These typically operate at 132kV alternating current (AC) or at 150kV direct current (DC) for developments further from shore. Array cables connect turbines to local offshore substations generally at 33kV today. The supply of export cables (especially DC) is more specialised, so fewer suppliers act in that market.

AC and DC substation electrical systems. Depending on the specific design used, AC systems may incorporate HV transformers, reactors, switchgear and associated power electronics, control and auxiliary systems. DC systems also incorporate HVDC converters. Although a number of major suppliers of HV electric components produce both AC and DC equipment, the HVDC market is less mature and is considered separately, here. Offshore substation electrical systems are mounted on platforms. The fabrication capability for platform topsides exists in the oil and gas sector and foundations are usually similar to those of turbines. However, few are required so steelwork fabrication for offshore substations is not considered a concern.

Steel and concrete foundations. Foundations support the turbine above the sea bed. Designs are driven by a combination of wind and wave loading and structural dynamics requirements. Steel monopile foundations currently dominate the market but, as larger turbines are

used in deeper water, other designs such as jackets will be used increasingly. Another key material for offshore foundations is concrete. The supply issues are distinct and they will be considered separately.

3.4.1 Subsea export cables

Landscape

The capacity for manufacturing HV subsea export cables is limited, with only three established players in the global market: ABB, Nexans and Prysmian. Since 2009 there have been two new entrants with at least one more to follow. NKT has opened a new factory in Cologne and has supplied the Baltic 1 offshore wind farm, due to be commissioned in 2011. Recently, General Cable has entered the market through its subsidiary NSW, winning the contract to supply HV cable to the Baltic 2 project from Nordenham on the River Weser. UK player JDR Cable Systems has received research and development funding to support its investment to develop and supply HV cables.

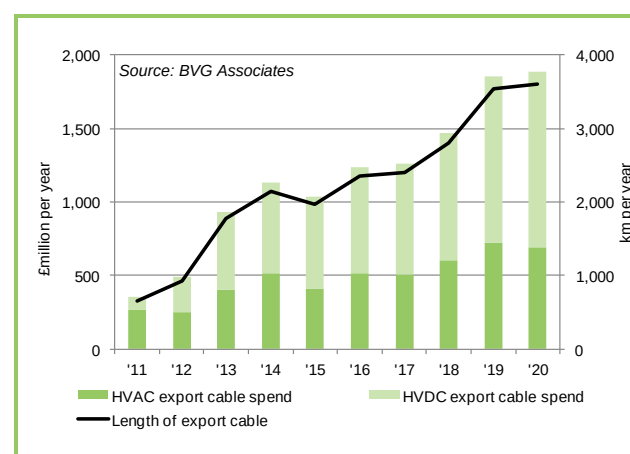


Figure 3.4.1. Forecast spend and demand for subsea HVAC and HVDC export cable for European offshore wind to 2020.

There is a consensus that when Round 3 construction begins in 2015 there will be a significant shortage of HV cables unless further investment in addition to that described above is made promptly. Most suppliers have expansion plans in place but are currently unwilling to invest without a firm commitment from customers that the projects requiring expansion will proceed in the timescales anticipated.

Figure 3.4.2 shows that, by 2014, about 4,000km of export core will be required to meet our forecast. Even with additional investment from established suppliers and new entrants, this indicates that export cable supply is likely to be extremely tight until 2014.

Currently, around 2,400km of cable core extrusion annual capacity exists to meet the subsea cable demand. This

BALANCE OF PLANT MANUFACTURE

Proven capability (examples only)	Export: ABB, Nexans, NKT, Prysmian Array: ABB, Draka, JDR Cable Systems, Nexans, Parker Scanrope, Prysmian	Substation electrical package ABB, Alstom Grid, Siemens T&D Transformer ABB, Alstom Grid, Siemens, Tironi	ABB Siemens T&D	Manufacture Aarsleff, NCC Construction Design Aarsleff, Grontmij	Manufacture Aker, BiFab, Blatt, SIF/Smulders, Weserwind Design LICengineering, MT Højgaard, OWEC Tower, Rambøll, SLP
Likely future capability (examples only)	General Cable, J-Power Systems, LS Cable, Viscas	Crompton Greaves, Hyosung, Hyundai, Mitsubishi, Prolec GE, SGB	Alstom Grid	Costain, Gifford, SLP, Strabag, various (continent)	Corus, EEW, H&W, Heerema, McNulty, SLP, TAG
Subsea cables (especially export cables) AC substation electrical systems DC substation electrical systems Concrete foundations Steel foundations					
Market Concentration	High (export) Medium (array)	High (for electrical package)	High	High	High
Issues	Export: - Limited supply of export cables, especially HVDC, and a lack of proven track record for new entrants. - Investment required ahead of other wind farm components.	Planning consent for onshore facilities.	- Limited supply. - Supply to specific projects is often bespoke. - Track record of suppliers. - Lack of availability of experienced power engineers. - EPC contracts could restrict competition.	Innovative solutions not proven.	- Limited jacket and space frame supply. - Time taken to bring new technologies to market.
Actions	Export: - Facilitate dialogue between existing suppliers and new entrants, and purchasers. - Standardise cable specification, design and supply. - Facilitate syndicated commitment from developers. - Provide support for inward investors establishing new facilities in the UK.		- Facilitate early engagement between developers and suppliers. - Standardise design and supply. - Develop networked HVDC solutions.		
Traffic light rating (see Section 3.1)	2011	2011	2011	2011	2011
	Was	Was	Was	Was	Was
Traffic light rating (see Section 3.1)	 for export				
	 for array				

equates to 1,200km to 1,200km of HVDC (2-core) or 800km of HVAC (3-phase) cable. Bringing a completely new line on stream in a new location can take up to four years, although it takes less time to extend existing capability. It takes up to two years to test and type certificate a new cable manufacturing facility and risk is attached to early supply from a new facility or supplier. Cables that will be installed subsea need to be loaded onto an installation vessel from the factory, which limits the number of sites where additional capacity can be built. Some existing suppliers with the potential for additional capacity in their factories asserted that it would be possible to expand production within 12-18 months and felt that this would be sufficient time given the other timescales inherent in the construction of offshore wind farms.

Our forecast European demand for export cables is shown in Figure 3.4.2 with multiple investments required in 2011 to ramp up supply by 2013. DC cable demand for offshore wind projects will increase significantly and will exceed that for AC cable by 2014. The length of cable assumes three-core AC cables and single-core DC cables, of which two are required for each connection. The demand curve does not match the shape of the GW installation forecast because it takes into account distance to the anticipated landfall for each project separately.

“All the signs are there to suggest the market is going to ramp up, because of the plans for Round 3, but at the moment we’re not seeing the commitments from developers that give us the confidence to expand our business.”

PRYSMIAN

One potential option is the use of paper-insulated cable for export applications, which can carry higher voltages. While it is normally used in interconnector projects and is more expensive and takes longer to manufacture than the cross-linked polyethylene XLPE insulated cable normally used, it may offer a solution for some projects.

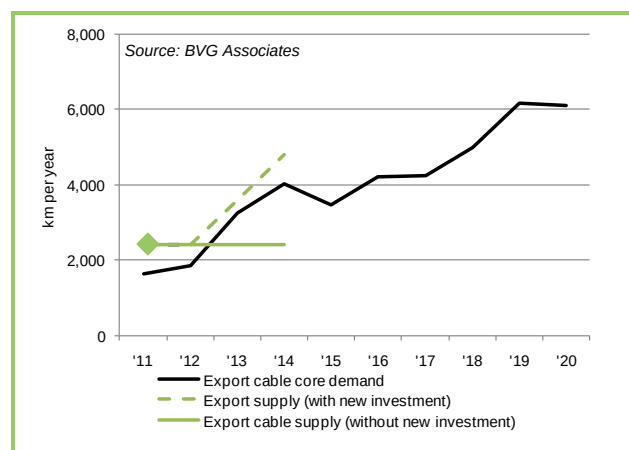


Figure 3.4.2. Forecast supply and demand for subsea export cable core for European offshore wind to 2020.

The voltage ratings on HVAC cables are rising, from the standard 132kV used in current wind farms up to 170kV and 245kV. HVDC cable is at present typically 150kV or 300kV and, again, this is expected to rise with improvements in insulation material design.

We anticipate that much of Round 3 and German offshore installation will have HVDC grid connections. To date, a range of HVDC links are operating, including subsea. The first offshore wind farm substation connected by a HVDC technology, BorWin1, was commissioned in 2010 to link the Bard 1 400MW wind farm. The connection is provided by a 200km HVDC twin feeder cable (125km offshore, 75km onshore) to a substation at Diele in northern Germany. ABB supplied the cables and converter stations. A further three HVDC connections have been contracted, also for German projects. The supply of HVDC converter technologies will be considered in Section 3.4.4.

Issues

Limited supply of export cables, especially HVDC, and a lack of proven track record for new entrants. With a concentrated market and limited manufacturing capacity, long-term concerns remain about the availability of high-voltage export cables, with the potential to constrain the delivery of offshore wind projects even if significant new investments are made in 2011.

Investment required ahead of other wind farm components. The time to test and certify new cables is lengthy and cables are needed before turbines are installed. The supply from new cable manufacturing facilities can require significant periods of product testing at high voltages. The situation is particularly acute for the manufacture of DC cables which is more specialist than for AC.

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Actions

Facilitate dialogue between existing suppliers and new entrants, and purchasers. The supply chain needs to give clear lead times to developers and dialogue needs to take place about how to facilitate progress towards new facilities at minimum shared risk and cost. Although developers may not know exactly what cable they may need for each project, they will have an overall requirement over a period of time which should enable them to make an agreement with a supplier in order to invest in new facilities. To date, we have not seen framework agreements in this space.

Standardise cable specification, design and supply.

This would serve to increase manufacturing efficiency and enable developers to order cable for flexibly to meet their requirements for a portfolio of offshore wind projects with less concern about project-specific variants. Currently, we see significant differences in purchasing requirements for cable to be used in similar applications.

Facilitate syndicated commitment from developers.

Collective commitments would be one way to lower risk and trigger investment in facilities without providing final details of the cables required at the time of initial commitment.

Provide support for inward investors establishing new facilities in the UK. The UK market will have a better chance of securing its requirements at competitive prices the more that local sources of supply are established.

3.4.2 Subsea array cables

Landscape

There are more manufacturers of medium voltage array cables connecting turbines to the offshore substation than of HV export cables and the barriers to new entrants and establishing new lines of production are lower. The industry does not expect array cables to constrain project delivery as most purchasers believe that the market will deal reasonably effectively with supply issues around these cables. Although new investment certainly will be needed, the growth in demand is less challenging than for export cables. In the UK, JDR Cable Systems has already made a significant investment to enter the market for array cables and has been rewarded with first orders.

Current lead times are quoted of 40 weeks for 33kV export cable and a ramp-up time to increase supply of only six to eight months. There have been suggestions that, due to the increased size of wind farms, there may be a benefit in increasing the array voltage from 33kV. So far, customers have only shown RD&D-level interest in such technology.

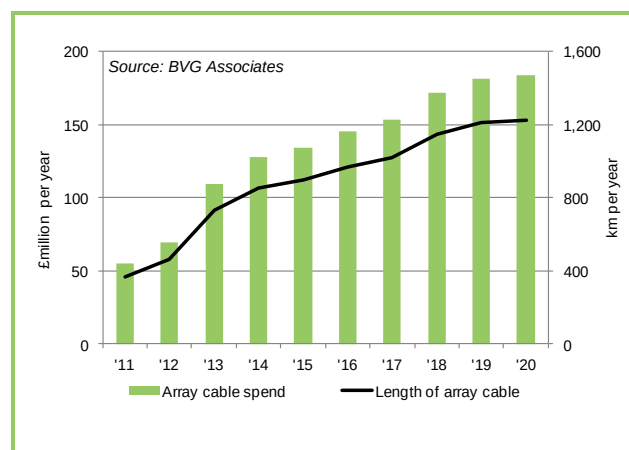


Figure 3.4.3. Forecast spend and demand for subsea array cable for European offshore wind to 2020.

The anticipated demand and spend on array cables for the European offshore wind market is shown in Figure 3.4.3. This forecast is based on an assumption of gradually decreasing cable use per MW installed, following the trend seen in wind farms installed to date due to the use of higher-rated turbines. This is partially offset by the associated use of larger rotors, thus increasing turbine spacing.

3.4.3 AC substation electrical systems

Landscape

AC electrical systems onshore and offshore include, medium and HV transformers, reactors and switchgear, and associated power electronics and control and auxiliary systems.

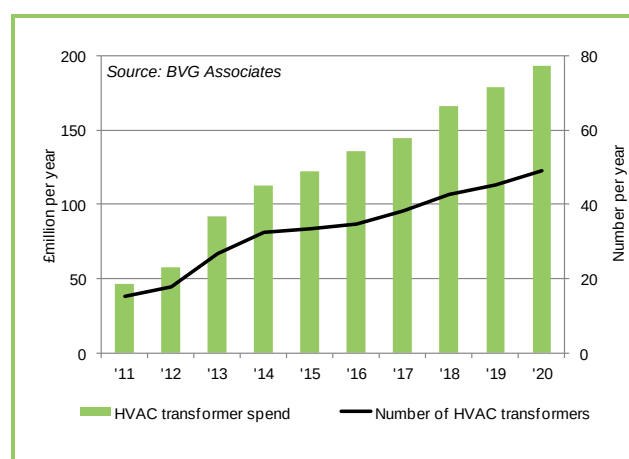


Figure 3.4.4. Forecast spend and demand for substation transformers for European offshore wind to 2020.

In our 2009 report, the feedback from the industry was that offshore substation transformers were an area of significant concern with lead times generally between two and two and a half years. The situation has improved markedly since then with lead times now below 18 months. It should be noted that lead times are driven by the global requirement for new electrical infrastructure at the time of order, rather than the specific requirements from the wind energy sector. While there are a small number of high voltage system integrators, they have a worldwide supply chain. We conclude that the supply of transformers, and hence HVAC supply as a whole, is less constrained than in 2009 and we see no strong reason for this situation to change significantly.

One concern about transformers is the risk of damage during operation with a consequent long outage and resulting lost revenue. Already, the substation transformer at Nysted offshore wind farm in Denmark has been replaced, with downtime for the whole wind farm of six months or so. The risk could be minimised with standardisation of substation specifications enabling a pool of transformers to be used on different projects and as spares.

Issues

Planning consent for onshore facilities. This has proved to be challenging at times. A substation even for a Round 2 wind farm such as London Array is a significant size, covering eight hectares including landscaping.

3.4.4 DC substation electrical systems

Landscape

HVDC technology provides a more efficient use of cables with two cores rather than three and lower transmission losses, avoiding the high capacitance of AC cable. Set against this is the cost of the converter systems located at each end of the cable. While the tipping point at which HVDC is generally chosen is currently about 80km, this is dropping over time as the cost of converter technology falls. The maximum power transmission per connection is also higher (now over 1GW as compared to 400MW for HVAC) and technical improvements, in particular the modular nature of voltage source converter technology, mean that the advantage is likely to increase. The reliability of HVDC converter stations has been demonstrated in other sectors, where availability is reported in excess of 99 per cent. With the increases in distance from shore for Round 3 projects, in time, we anticipate that most projects will be connected via HVDC links.

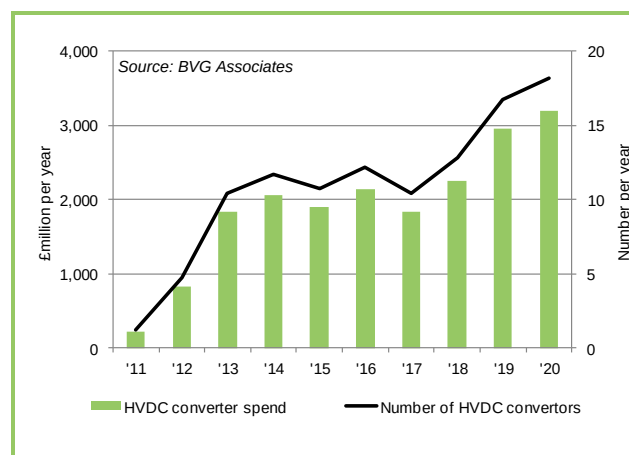


Figure 3.4.5. Forecast spend and demand for substation DC converters for European offshore wind to 2020.

There are currently two suppliers of HVDC converter technology to subsea projects: ABB and Siemens. A third, Alstom Grid (a division purchased from Areva T&D in 2010), has invested in a demonstrator facility at Stafford in the UK and has ambitions to capture a significant share of the offshore wind market. One supplier indicated that the ramp up of supply can be achieved within nine months and hence should not be of concern to customers. Nevertheless, developers are concerned both at the limited amount of competition in the market and at suppliers' ability to meet demand. Indeed, there is interest in supporting the development of at least one new competitor, likely to be from Asia.

A major development in HVDC technology will be the eventual supply of networked solutions, allowing the linking of offshore wind farms via an HVDC grid. Today, all links are point-to-point, with a converter each end. There is significant focus in this area from a number of players.

Issues

Limited supply. While this is a source of concern, the industry reports that suppliers are open to invest when commitments to purchase are made. Lead times are relatively short.

Supply to specific projects is often bespoke. Currently, electrical systems are normally designed for specific wind farms. Concerns about supply would be eased if developers were able to commit to purchasing earlier in the knowledge that systems could be used at any of a number of projects within their portfolio.

Track record of suppliers. Only one DC offshore wind grid connection has been installed to date. The more mature interconnector market is closely related and new HVDC suppliers should have an opportunity to prove their

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technology at lower risk in this market if both terminals are onshore.

Lack of availability of experienced power engineers.

Suppliers have expressed concern over the lack of available engineers, partly due to high demand from other sectors. A number of players have reported that they are investing heavily in recruitment and training of engineers. They expect to be able to address this shortfall if actual project approvals provide for a smooth ramp up in demand. Two suppliers have suggested that if projects are delayed then the related internal investment could be at risk, which would impact on the delivery of Round 3 sites later in the decade.

EPC contracts could restrict competition. If developers look to contract a single grid connection package, it may limit the ability of new entrants to enter the market.

Actions

Facilitate early engagement between developers and suppliers. This should facilitate earlier investment decisions by suppliers and support the entry of new players. We understand that in several cases these discussions are underway, although uncertainty over the OFTO regime has delayed these in some cases.

Standardise of design and supply. Agreed standard interfaces and design parameters would enable more efficient use of production facilities and earlier commitment to purchasing hardware that could be used on more than one project.

Develop networked HVDC solutions. Eventually, this will decrease the need for such long links between individual wind farms and the onshore transmission grid.

3.4.5 Concrete foundations

Landscape

Feedback from developers is that, unlike in the more benign conditions of the Baltic, concrete foundations will struggle to gain a significant market share in the UK, although this perception may change after further wind farm design. Despite this, a number of technologies are being developed, notably by Strabag in Cuxhaven and by a consortium led by Gifford and supported by the Carbon Trust, that also incorporates an innovative installation method reducing the marginal cost of that activity. Obstacles to market penetration include:

- The lack of cost-effective, proven concrete foundation designs for offshore wind for deeper water sites;
- The lead time for specialist installation vessels; and

- A short-term requirement for labour intensive fabrication.

No supply chain constraints are foreseen should concrete become widely used.

Issues

Innovative solutions not proven. The applications of concrete foundations have been mainly in shallow water to date.

3.4.6 Steel foundations

Landscape

To date, the majority of offshore foundations have been manufactured from steel and the vast majority of these have been cylindrical monopiles. As water depth and turbine size increase (leading to greater tower-top mass and decreased wind loading frequencies), we anticipate that there will be a significant move towards alternative designs of foundations, including jackets, tripods and suction buckets for certain ground conditions. In deeper water, other concepts will be used, including tension-leg and other floating designs, although there is minimal need for such technology for Round 3 projects.

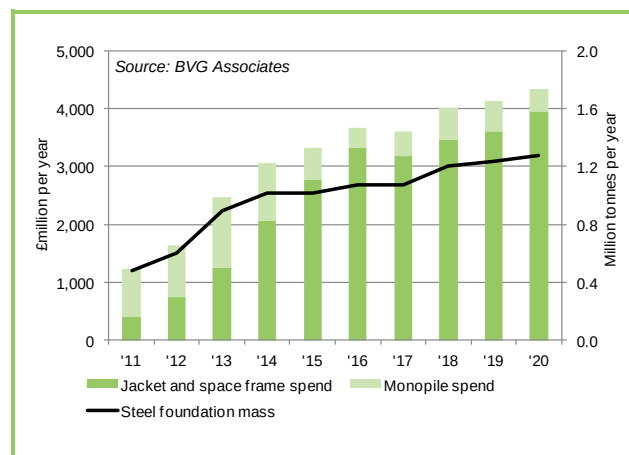


Figure 3.4.6. Forecast spend and demand for steel foundations for European offshore wind to 2020.

Although existing supply is well below the eventual demand and few players currently service the market, ramp up times are relatively short (less than two years) and a good number of players (including those currently manufacturing wind turbine towers at inland locations) could locate new businesses coastally to supply. Steel foundation manufacture offers significant opportunities for UK businesses. While SIF/Smulders has captured a significant market share of the monopile market, more players seem likely to enter the market. In the UK, TAG has attracted investment for a new monopile manufacturing facility on Teesside and Corus has announced that it intends to

manufacture monopiles at its Redcar site, also on Teesside. As lead times for establishing rolling and welding lines are relatively short, we found no concern from purchasers over the supply of monopiles.

Currently, practically all jacket structures for offshore wind turbines have been supplied by UK's Burntisland Fabrications (BiFab). Again, other continental and UK players have established facilities or have signalled their intent to do so. Players manufacturing towers or steel foundations are well placed to provide transition pieces and source other auxiliary steelwork. Other processes such as surface finishing and fit-out likewise require close quality control but will not cause bottlenecks.

Should all the players showing interest win long-term business, the market will be well served, even without the prospect of further new entrants from Europe and beyond.

Likewise, we do not believe steel supply will be a significant constraint, with European offshore wind requiring a modest proportion of current European hot rolled flat product supply. In 2009, we identified steel foundations as an area of concern; two years later the situation has improved.

Issues

Limited jacket and space frame supply. The forecast demand and value of steel foundations for the European offshore wind market are shown in Figure 3.4.6. There will be a move to non-monopile structures as they become the most cost-effective (or in some cases the only designs deliverable) for a given site, following the trend seen in wind farms contracted to date.

To date, only BiFab (jackets) and Bard (tripods) have a track record in the supply of non-monopile support structures and we heard concerns from some developers about the number of fabricators needed to supply the future market. We believe that there is enough interest from companies with offshore fabrication capability to suggest that supply will not be a problem as new facilities can be bought on line relatively quickly.

Time taken to bring new technologies to market. The cost of foundations is a significant fraction of wind farm CAPEX and innovation in production methods will be seen as suppliers push to reduce costs. Innovation may raise new supply concerns as it takes time to develop suitable manufacturing technology to produce new designs efficiently. Investment is needed not simply in increasing the number of manufacturing lines but also, for example, in increasing mechanisation in the manufacturing process for jackets and in fewer-pass welding for really thick joints, such as by using TWI's electron beam technology.

3.5. Installation and commissioning

Installation and commissioning covers work on all balance of plant as well as turbines. It can be broken down into the following areas: export cable-laying; foundation installation; array cable-laying; construction facilities; offshore substation installation; sea-based support; turbine installation; and commissioning. Of these, this section will focus on the following, most significant areas:

Wind farm construction facilities. While several UK ports have been used to date for offshore construction, the scale of Round 3 developments will require more ports with larger lay-down areas. The availability of port infrastructure for turbine manufacture and O&M support are covered in Sections 3.3.1 and 3.6.3.

Foundation and turbine Installation. This includes transport to the wind farm site and installation, including scour protection, transition piece installation, J-tubes and ancillaries and then, later, the installation of turbines.

Subsea cable installation. This includes both array and export cables and their termination in turbine electrical panels and at the offshore substation.

Civil engineering and construction management. This includes delivery of specific supply contracts within an EPC or multi-contract environment.

Onshore electrical installation and grid connection. This covers substations and cable-laying and, aside from consenting issues, generally is not considered an area of concern, as it usually employs widely used resources from across the power industry.

3.5.1 Wind farm construction facilities

Landscape

The need for offshore wind farm construction facilities is now well understood by UK port owners, with a growing number of development proposals being put forward in advance of decisions about the installation strategy for Round 3 projects. Construction facilities may either be developed as part of an integrated wind turbine manufacturing facility (considered in Section 3.3.1) or as a stand-alone site. Investment in manufacturing facilities is more likely to be made on the UK's east coast and it is likely that these will also be used for project construction. Greater use of stand-alone construction ports will be made for projects further away from the large manufacturing facilities but which still have sizable markets, such as the Irish Sea. Investment in construction-only facilities on the UK east coast may be risky in that installation strategies here may not rely on local construction facilities.

INSTALLATION AND COMMISSIONING									
Proven capability (examples only)	Barrow, Belfast, Dunkirk, Eemshaven, Esbjerg, Harwich, Ijmuiden, Mostyn, Ramsgate, Vlissingen	A2Sea, Ballast Nedam, Bard, Geosea, Jack-Up Barge, Marine Construct International, MPI Offshore, Scaldis Salvage	Global Marine Systems, Mika, MPI, Nexans, NKT, Offshore Marine Management, Peter Madsen Rederi, P&O Maritime Services, Prysmian, Subocean (Technip), Visser & Smit	Ballast Needam, Bilfinger Berger, CB&I, Fluor, Hochtief, KBR, MT Højgaard, SLP, Van Oord, various supporting consultancies					
Likely future capability (examples only)	Various	Beluga, Fred Olsen, GAOH, Gulf Marine Services, Hochtief, RWE Innogy, SeaJacks, Seaway Heavy Lifting, Seawind	Beluga Offshore; various oil and gas players	AMEC, Costain, Wood Group; various oil and gas players					
Wind farm construction facilities					Turbine and foundation installation		Subsea cable installation		Civil engineering and construction management
Market Concentration	High	Medium	Medium	Medium	Medium	Medium			
Issues	Lack of suitable construction facilities for smaller remote developments.	- More constrained vessel availability for the most challenging projects. - Limits to the suitability of jack-up solutions. - High cost of installation using conventional jack-up solutions.	- More constrained vessel availability for the most challenging projects. - Limits to the suitability of jack-up solutions. - High cost of installation using conventional jack-up solutions.	- Lack of experienced personnel. - Frequent damage during and after installation. - Availability of suitable vessels. - Foundation designs do not fully consider cable issues. - Cable installation requirements not fully incorporated into project plans.	- Lack of experienced personnel. - Frequent damage during and after installation. - Availability of suitable vessels. - Foundation designs do not fully consider cable issues. - Cable installation requirements not fully incorporated into project plans.	Limited experienced skills base.			
Actions	- Improve the understanding of Round 3 developers' needs for construction facilities among port owners and potential investors. - Encourage government support for further port infrastructure investment.	Harmonise installation methods.	- Encourage early engagement of cable installation contractors in wind farm design and construction planning. - Encourage dialogue between cable manufacturers, installers and designers of interfacing components. - Standardise foundation design.						
Traffic light rating (see Section 3.1)	2011	Was	2011	Was	2011	Was	2011	Was	Was
	A	A	A	R	A	R	A	G	A

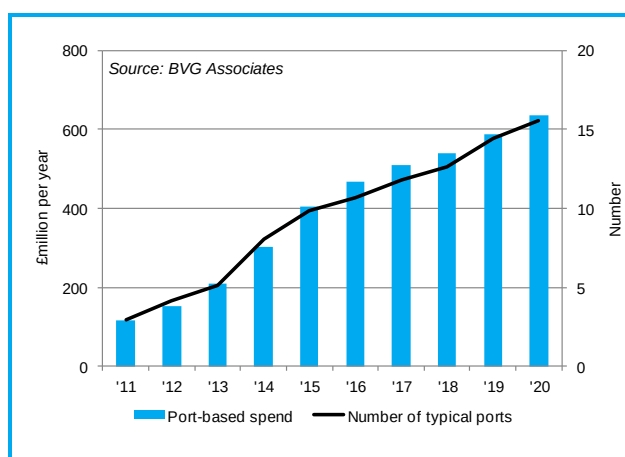


Figure 3.5.1. Forecast spend and demand for construction ports for European offshore wind to 2020.

The anticipated demand for construction facilities is shown in Figure 3.5.1. This forecast is based on the assumption that the construction facility may be co-located with a turbine assembly facility and other major component manufacture, although non-construction costs and space are not included. The minimum requirements for a typical construction facility are 12 hectares, 200-300m quay length, water access to accommodate vessels at least 140m long with a beam of 45m and 8m draft, no tidal restrictions and no overhead restrictions below 100m. We assume that such a facility could install up to 500MW per year. The ratio of area to MW capacity is not expected to change significantly in the future, despite the increasing rating of turbines, as these larger designs will require more space and quayside for storage and handling. The demand for UK ports from offshore wind is discussed in more detail in a report prepared for DECC in 2009.¹⁹

“Ports need to have a long term future - if they are just used for a one-off project then the developer may have to carry the cost of upgrading them.”
ROUND 3 DEVELOPER

In reality, instead of seeing 20 or so similar-sized facilities developed, we expect that a core of four or five large hubs will be located mainly on the North Sea coast that are

supplemented by a number of smaller ports of the size described. The total value of port-based spend for wind farm construction (excluding wind turbine manufacture) in the period to 2020 is in the order of £1.2 billion.

Issues

Lack of suitable construction facilities for smaller remote developments. For the larger Round 3 projects that will be built over a number of years, developers are expected to agree long-term contracts for construction facilities. In these cases, ports can use this commitment to secure investment to develop facilities within the timescale needed for delivery. For smaller zones that are more remote from other areas of significant activity, developers may not be able to offer the long-term commitment that will allow port owners to make the necessary investment to enable efficient construction. In this case the cost of redevelopment may need to be borne by the wind farm project.

Actions

Improve the understanding of Round 3 developers' needs for construction facilities among port owners and potential investors.

Encourage government support for further port infrastructure investment. The industry should support the government proposals for port infrastructure development and look for more as this will unlock further private sector investment and job creation.

3.5.2 Turbine and foundation installation

Landscape

There is a significant global fleet of offshore construction vessels mainly supplying the oil and gas industry. So far, offshore wind has made use of these vessels only when the small purpose-built fleet is fully occupied as the requirements of offshore wind are today quite specific: offshore wind requires multiple relatively high lifts (typically with hook heights of 100m) at different locations coupled with the transportation of a large number of components and relatively fast transit speeds. In 2009, installation vessels were a major concern as, while there were a few specialist offshore wind installation vessels, most were small with limited crane capacity and none could operate in the deeper waters of upcoming projects. With the recognition of a need for a new generation of vessels, a lack of confidence in the market suggested that little investment was likely without firm orders

¹⁹ *UK Ports for the Offshore Wind Industry: Time to Act*, Department of Energy and Climate Change, February 2009. www.berr.gov.uk/files/file49871.pdf. Last accessed 24 January 2011.

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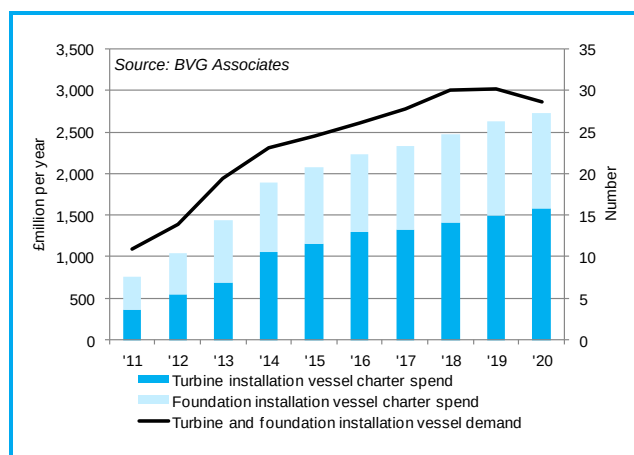


Figure 3.5.2. Forecast charter spend and demand for turbine and foundation installation vessels for European wind to 2020.

Figure 3.5.3. shows that the landscape has changed significantly for the better since 2009, with a number of new vessels now operating or under construction. While the eight small vessels that have been used in turbine installation to date are likely to be used only for operations and maintenance purposes, we estimate that there will be 22 larger specialised offshore wind installation jack-up vessels available in the market by 2014.

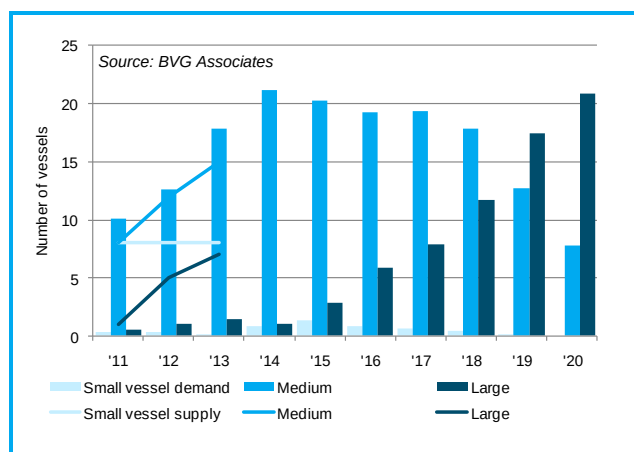


Figure 3.5.3. Forecast supply and demand for turbine and foundation installation vessels for European wind to 2020.

In Figure 3.5.3, we have made a distinction between the supply and demand for vessels that we have categorised as small, medium and large. The distinction is somewhat subjective but it is largely a function of operating depth, crane capacity and deck space. For example, a large vessel might have an operating depth of greater than 50m, a crane capacity of 750 tonnes or more, and a beam of over 45m. We have mapped these vessel sizes onto the likely requirements of forthcoming European projects,

assuming that turbine and foundation installation will be undertaken by the same pool of vessels. A few projects to date have used heavy lift vessels or sheerleg cranes such as the Svanen or the Rambiz for foundation installation. We do not expect that these types of vessel will be used significantly when the availability of specialist wind farm installation vessels improves. There will be limited need for the small vessels used to date and a slight undersupply of medium-sized vessels, but this is mitigated by an early over-supply of large vessels, which can be used in place of medium-sized vessels.

The issue of installation vessel availability has not completely disappeared for developers. Although feedback is of a much improved picture, there are concerns that many of the new vessels have been designed for typical Round 3 sites with the result that the availability of specialist for more challenging sites, such as those in the deepest water, with large tidal ranges or greatest distance from shore, may be more constrained.

Figure 3.5.3. also shows that, towards the end of the decade, large vessel demand increases significantly. We anticipate that this demand may change as a result of innovations in installation techniques, for example the “float out and sink” of complete turbines and foundations.

Historically, the cheapest foundations for most projects to date have been monopile structures. As projects are constructed in deeper water and with larger turbines (both heavier and slower rotating), the dynamics of the overall structure mean that it becomes difficult to design and install a structurally efficient monopile. Currently, designs are compromised further due to the lack of tooling for very large monopiles, and specifically large diameter anvils (each designed for a specific monopile diameter). Two main players, IHC and Menk, have provided tooling for most offshore wind monopile installations to date where driving has been chosen and new anvils will be required as larger monopiles are produced. Most developers understand that they need to secure the availability of such tooling before decisions are taken to manufacture such monopiles. One way to reduce the size of anvils required for some ground conditions is to use conical-topped monopiles, but this introduces additional monopile manufacturing complexity and cost.

Our feedback from developers is that concrete foundations are likely to have a limited role to play in future UK offshore wind projects. Installation methods and vessels for gravity base foundations are completely different from those for monopiles. Therefore, a constraint on the use of concrete foundations may be the availability of suitable vessels. A number of the concrete foundation solutions include bespoke installation vessels as part of the rationale for reduced costs. Although these vessels will be cheaper than the installation vessels employed for steel foundations,

investment in these vessels need to be made in connection with relatively small orders for demonstration projects.

“We’re not entirely convinced the right vessels are coming available. The jack-up solution is still relatively limited to shallow sites.”

A ROUND 3 DEVELOPER

Issues

More constrained vessel availability for the most challenging projects. Vessel operators have made logical decisions to specify new builds that meet the needs of typical projects, leaving problems especially for deeper water sites.

Limits to the suitability of jack-up solutions. The industry has not sought to repeat the installation strategy used for the Beatrice demonstrator, but innovations will be needed before projects exceed the practical operating depths for jack-ups.

High cost of installation using conventional jack-up solutions. Opportunities for CAPEX improvement should be focused on alternative installation methods that eventually will not rely on such expensive vessels.

Actions

Harmonise installation methods. It is anticipated that we will see innovation in a number of areas of installation and a widening in the number of approaches to installation before any future harmonisation on preferred methods takes place. Initiatives such as the Carbon Trust’s Offshore Wind Accelerator have sought to find new solutions.

3.5.3 Subsea cable installation

Landscape

In 2009, we reported significant concerns about cable laying, based on incidences of cable damage during or after installation and coupled with the commercial difficulties of various players. While quality and commercial problems have persisted, there have been new entrants to the cable-laying market and encouraging signs of new investment by installation contractors for example: Nexans’ modification of the Skagerrak; Subocean’s long-term charter of the Polar Prince; and ABB’s charter of the new build AMC Connector. We are aware of one cable installation company that is currently investing in two new vessels to meet short-term demand, recognising that further investment will be needed to meet longer-term project requirements. In addition, there has been further interest from the oil and gas industry, although investment is yet to materialise.

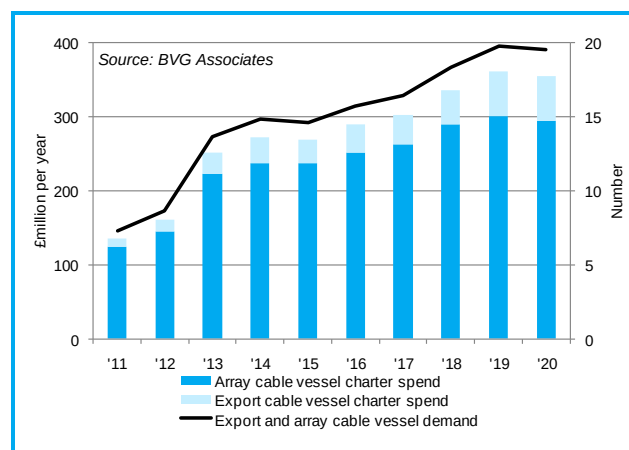


Figure 3.5.4. Forecast charter spend and demand for export and array cable installation vessels for European wind to 2020.

For installing Round 1 and 2 export cables, anchored barges with a shallow draft that can beach for the near-shore cable laying have generally been used. Such barges will be unsuitable for projects further offshore and the use of DP2 vessels with high capacity cable carousels onboard will become more widely used. Export cables can be laid at 150-200m/hour for simultaneous burial and 500m/hour for free-laying.

Array cable laying largely will be undertaken using smaller specialist DP2 vessels with lower carousel capacities. In addition, there has been positive innovation in the use of subsea cable-laying tractors. The major challenge in array cable installation is the high level of work required to be carried out offshore when pulling in and terminating the cable at each foundation. Another challenge is the need to dovetail activity with other installation contractors.

On balance, with new entrants to the market, positive signs of investment in new or modified vessels, and a gradual improvement in efficiency and quality, we believe that the situation has improved since our analysis in 2009.

Issues

Lack of experienced personnel. About 70 per cent of the skills needed for offshore wind cable installation are transferrable from sectors such as telecommunications cable-laying. Given the unique requirements of the task, the remainder can only be acquired through experience. With the growth in demand, there is an inevitable learning process and few people have sufficient experience to manage first-rate activities.

Frequent damage during and after installation. Cable damage has been the largest source of insurance claims relating to offshore wind farms. There are a wide range of causes of this damage that in part will be removed through

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the use of suitable vessels and the employment of experienced contractors and personnel. The requirements of both vessels and personnel are now better understood. Technical, commercial and consenting issues also need to be addressed in order to reduce the lifetime cost of subsea cables, including export cables.

Availability of suitable vessels. The largest cable-lay vessels have carousel capacities of 6000-7000 tonnes, coinciding with the upper limit of cable manufacturers' storage capacity. Vessels of this size will be needed for Round 3 export cable installation where 7000 tonnes of cable represent around 100km. Currently, there are only two such vessels operating, with a third due for delivery in 2012. Peak demand will be around four export cable laying vessels (see Figure 3.5.4). This assumes that, for a HVDC connection, half of projects will install two single-core DC cables simultaneously and half will lay them separately.

For array cable-laying, the equivalent of about 16 vessels will be required for European offshore wind by 2020. There is greater global availability of these smaller cable installation vessels, although few are ideally suited to offshore wind work without being modified to carry specialist equipment.

While the demand from offshore wind suggests that only two more export installation vessels will be required, the sector faces significant competition for such marine assets from the oil and gas industry and interconnector projects. The availability is therefore likely to be tight and some new investment will be needed. The lead times are 18-24 months and 12-18 months for new build and vessel modification respectively. The time from contract award to the start of installation is likely to be approximately 18 months and so decisions to modify could be made within this timeframe. Framework agreements between developers and installation contractors would provide the confidence needed to facilitate investment.

Foundation designs do not fully consider cable issues. Concerns remain that foundation designs still do not fully consider the ease of array cable termination at the turbine transformer. Standardisation of foundations and cable termination arrangements with due consideration of facilitating rapid offshore working would be beneficial.

Cable installation requirements not fully incorporated into project plans. Developers wish to minimise the number of vessels on site and maximise the rate of foundation installation. This would appear to reduce costs but it can also reduce cable installation efficiencies. A mismatch between the foundation installation rates and the array cable installation rates can have a significant impact on construction times. Array cable pull-through is time consuming but could be assisted, for example, through the use of additional large vessels used to transfer crews to

foundations in challenging weather conditions. This is because, in general, cable installation vessels can work at significant wave heights of 2.5-3m, which is greater than for many workboats. This has the result that cable installation may be delayed by the lack of access of workers to the foundations.

Actions

Encourage early engagement of cable installation contractors in wind farm design and construction planning. This could increase the compatibility of design and installation methodologies.

Encourage dialogue between cable manufacturers, installers and designers of interfacing components. Deeper three-way engagement has the potential to accelerate improved designs and processes where existing dialogue seems to have had little impact.

Standardise foundation design. Harmonisation could minimise problems by increasing confidence in methodologies employed across projects and enabling efficiencies in working practices to be improved rapidly with time.

3.5.4 Civil engineering and construction management

Landscape

In the very earliest offshore wind projects, the wind turbine manufacturer often took management responsibility for construction activities under an EPC contract. As the market has progressed, developers have chosen to use multiple supplier contracts (MSC), project-managing delivery and sometimes using specialist construction management providers to work alongside them. For Greater Gabbard, Airtricity (now Scottish and Southern Energy) followed the EPC contracting route, this time using long-term project partner Fluor, a construction management provider, to deliver the full project. Whether EPC, MSC or using combinations of both with framework supply agreements and some more collaborative arrangements, significant construction management resources are needed in all projects. In offshore wind this is in relatively short supply. There are a number of highly competent players, especially from oil and gas and other infrastructure supply, that are yet to manage offshore wind farm construction and it is likely that we will see these enter the market in due course. However, there is concern about the cost of oil and gas teams and the methods they may choose to adopt.

For many projects, FEED activities are becoming more detailed. Such studies enable more focused procurement, reduce project contingencies and post-consent timescales and can facilitate innovation on a range of levels.

Issues

Limited experienced skills base. There are few people with long-term experience in offshore wind construction, but there are possibilities to draw in skilled people from other sectors. The challenges of the effective delivery of offshore wind projects with a fair degree of repeated process are similar but different from oil and gas and other infrastructure work, which is frequently dominated by single, high value activities.

3.6. Operations and maintenance

Issues relating to O&M are considered under the following headings:

- **Maintenance.** Maintenance can be broken down into planned activities (much of which could be classed as inspection, but also includes routine exchange of wear parts and planned replacement of major components) and unplanned maintenance in response to faults. Unplanned maintenance often requires spares and vessels at short notice. Both types of maintenance are dependent on good access to turbines.
- **Operations.** This includes monitoring of wind farm performance and management of maintenance activities.
- **Onshore facilities.** Maintenance is supported from onshore facilities, used for administration, refurbishment and storage of spares.
- **Transport and offshore accommodation.** Transport of personnel offshore may involve both vessels and helicopters. There is a move away from helicopter access from some asset managers, following a trend in the oil and gas industry. Further thinking is underway regarding offshore accommodation for wind farms far from shore and those close to other wind farms where facilities could be shared, reducing transit times significantly.

3.6.1 Maintenance

Landscape

Currently, almost all commercial offshore wind turbines are either in warranty or maintained under a long-term service agreement by the wind turbine manufacturer. UK asset managers are starting to consider the issues raised by increasing numbers of onshore turbines coming out of warranty by developing maintenance and support strategies. The three main options for maintenance are:

- Continue to purchase from the turbine manufacturer;
- Move to using a third party service provider; or
- Establish in-house maintenance expertise.

A number of utilities advise a strategy of using in-house expertise from their other power generation support functions for maintaining onshore wind turbines and using specialist third-party service providers (such as blade and gearbox specialists) where necessary. It is anticipated that more asset managers will continue to purchase offshore maintenance from the turbine manufacturer given the additional level of risk associated with the technology. We suggest that those asset managers with stronger technical teams have a better chance of securing a relationship with their maintenance provider that leads to long-term reliable turbines. Third party providers are likely to provide specialist access and repair/retrofit support to wind turbine manufacturer staff for complex tasks.

The expected number of European offshore turbines coming out of warranty is shown in Figure 3.6.1, based on a long-term assumption of a five year warranty period for an offshore plant.

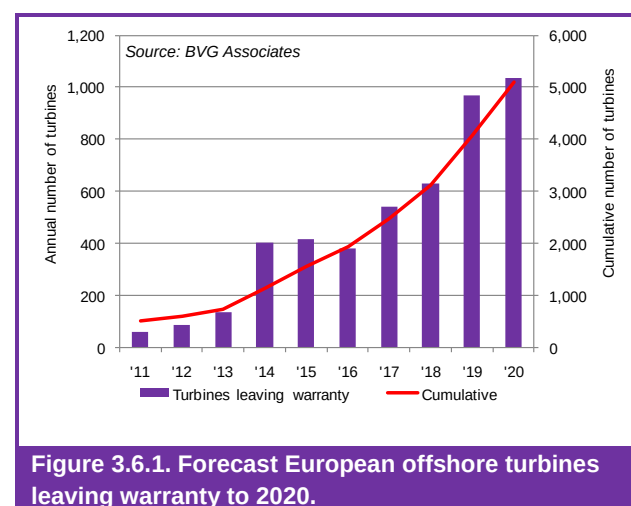


Figure 3.6.1. Forecast European offshore turbines leaving warranty to 2020.

Issues

Dependence on wind turbine manufacturers. Currently, asset managers advise concern about over-reliance on wind turbine manufacturers for the support of turbines, both in and after the warranty period. During the warranty period, more third party technical expertise is needed to provide independent advice. Asset managers with turbines out of warranty are also seeking additional third party technical capability for component inspections, repairs and refurbishment, particularly for gearboxes and blades. Currently, there are few players in the UK offering such maintenance services even onshore but the situation is starting to change quite rapidly.

Limited sharing of operational experiences. We see that, in some cases, operators are starting to share experiences and technical information more readily to enable them to maximise the performance of their assets,

OPERATIONS AND MAINTENANCE

Proven capability (examples only)	Turbine manufacturers	Wind turbine manufacturers, wind farm asset managers	Various UK (usually closest port to the wind farm)	Bond Air Services, MPI Workboats, North Sea Logistics, Offshore Wind Power Marine Services, Turbine Transfers, Windcat Workboats
Likely future capability (examples only)	Onshore wind O&M players that may extend to offshore, offshore and oil and gas contractors	Offshore/oil and gas contractors, or operations teams from parallel sectors	Various UK	Various others, especially from oil and gas
Operations				
Onshore facilities				
Transport and accommodation				
Market Concentration	High	High	Medium	Medium
Issues	- Dependence on wind turbine manufacturers. - Limited sharing of operational experiences. - Lack of skilled resource.	Complexity increases with the number of assets.		- Lack of large vessels. - Turbine access. - Impact of new maintenance strategies.
Actions	- Raise awareness of anticipated offshore skills needs. - Maximise sharing of maintenance learning.	- Maximise the sharing of operational data and learning. - Establish strategic partnerships.		- Raise awareness of anticipated offshore skills needs. - Develop new transport and accommodation solutions with special reference to health and safety.
Traffic light rating (see Section 3.1.)	2011	Was	2011	Was
	G	A	G	G A

though such activity is limited by a lack of resource and the contractual agreements in place with wind turbine manufacturers.

Lack of skilled resource. Turbine manufacturers, asset managers and third party maintenance service providers are all stating that acquiring skilled resources is likely to become an issue. Transferable skills from oil and gas, onshore wind other relevant sectors can be utilised, but there are some concerns that the increasing distance from shore of many projects will impact staff needs still further and limit the pool of people willing to take on the work. The issue of finding suitable staff is seen by many developers to be the primary responsibility of the turbine manufacturers as they arrange the first maintenance on each site, after which staff often transfer to a new employer in order to continue in the same role.

Actions

Raise awareness of anticipated offshore skills needs. Students at school and university and people in work with transferable skills need to be more aware of the skills and opportunities. Greater political awareness of the employment opportunities in offshore wind could lead to the introduction of further training provision.

Maximise sharing of maintenance learning. Lessons learnt from Round 2 and European projects need to be better applied in defining future O&M strategies for more challenging sites.

3.6.2 Operations

Operation includes monitoring the performance of the wind farm, both onsite and remotely, planning maintenance schedules, managing customer and supplier interaction and addressing all other commercial obligations.

“We are seeing a lot of people coming into the market with new ideas. We are taking into account the O&M requirements throughout the whole project development process.”
RWE NPOWER RENEWABLES

Issues

Complexity increases with the number of assets. As a wind farm owner's portfolio of projects grows, so will the number of different turbine designs and balance of plant assets that need to be managed.

Actions

Maximise the sharing of operational data and learning. This would enable the industry to identify and address repeat faults in components early, thus driving down operational costs and increasing revenue.

Establish strategic partnerships. As players grow larger portfolios of similar projects, framework agreements become easier to establish, under which the introduction of new hardware and processes frequently is easier to de-risk.

3.6.3 Onshore facilities

Landscape

The maintenance base houses crew areas and spare parts as well as the transport vessels. Typically, wind farm operators will look to use the nearest port that meets its specification in order to minimise travelling time and make the best use of weather windows. Ideally, the buildings are close to the quayside to minimise the time loading support vessels. For near-shore wind farms, each support vessel will need a 20m berth. A 500MW wind farm may require the operation of around seven vessels, depending on the distance to shore. Wind farms further offshore are likely to use hotel vessels and larger maintenance vessels. These will require berths for vessels over 100m long. Although these berths may not need to be dedicated, operators will want priority access and adjacent warehousing. A landing area for helicopters is also a likely requirement.

We are unaware of any supply issues that will constrain the supply of suitable facilities as long as early planning is carried out.

3.6.4 Transport and accommodation

Landscape

Round 1 and 2 wind farms are being maintained from a base at a nearby port. The relatively short distances to port make transportation by small vessels (in the order of 20m length) a viable solution. As the distance from shore and the size of wind farms increase, such vessels will no longer be the optimal transportation solution. For example, Siemens Wind Power has used helicopters for personnel transportation to Greater Gabbard. Some Round 3 wind farm sites that are likely to be maintained from onshore bases will take well over an hour to reach by vessel.

For even larger and more distant Round 3 wind farms, the offshore wind industry is likely to follow the trend of the oil and gas industry with the use of founded or floating hotels rather than solely using helicopters. Personnel will stay away from land for many weeks, using vessels or helicopters to transfer from the main offshore base to individual turbines. Horns Rev 2 off the Danish west coast is the first offshore wind farm to have some level of

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offshore accommodation, and recently Greater Gabbard used a dedicated accommodation vessel during installation.

Compared with two years ago, we see that the industry better understands the challenges of personnel transport to offshore farms and that there is increased input from the oil and gas industry. We need to see further progress but believe that there is sufficient time to address outstanding concerns before Round 3 activities commence.

Issues

Lack of large vessels. There are some concerns about the availability of large vessels for O&M, with vessels potentially being tied up in construction work. There is also a need for purpose built vessels in a range of sizes to meet O&M requirements and we are starting to see the development of such vessels.

Turbine access. Currently, access between the vessel and turbine is limited by sea conditions. There are particular concerns over health and safety aspects of personnel transfers, amplified by the greater distances to medical facilities for Round 3 projects. In the oil and gas industry, more innovative solutions have been deployed to minimise the lost time of not being able to get personnel safely onto the rig. Similar innovations are being developed for offshore turbine access, aided by the Carbon Trust's Offshore Wind Accelerator Access Competition, for example.

Impact of new maintenance strategies. In response to the significant changes in operating conditions, new strategies for maintenance and staffing will be required. In some cases, these may impact the design of turbines and installation methods, so consideration needs to be given to this area at an early stage. There are some concerns that the new strategies likely to be adopted for further offshore projects will require significant further development.

Actions

Raise awareness of anticipated offshore skills needs. It is relatively easy to establish aggregate resource needs assuming predicted levels of reliability.

Develop new transport and accommodation solutions with special reference to health and safety. There is still time to design and implement new solutions but these need to be developed under a robust framework of safety far offshore.

3.7. Supporting services

A number of supporting services are relevant to two or more areas of the supply chain or are independent of the wind farm development, construction and operating

phases. These can be categorised under the following headings:

- RD&D and testing activities, including at universities;
- Training, including technical, and health and safety;
- Enabling activities, including by public bodies and trade associations;
- Supply of health and safety equipment; and
- Supply of tooling, consumables and materials.

We will focus on RD&D and testing as we believe that there are few issues in the other supporting services not covered elsewhere in this report.

SUPPORTING SERVICES	
Proven capability (examples only)	Onshore turbine test sites Cuxhaven (DE), Høvsøre (DK), Wieringermeer (NL) Offshore demonstration sites Alpha Ventus (DE) Shared large component test facilities Cener (ES), Fraunhofer IWES (DE), Narec (UK), WMC (NL)
Likely future capability (examples only)	Offshore demonstration sites see Table 3.7.1. Shared large component test facilities LORC (DK)
RD&D and testing	
Market Concentration	High
Issues	• Limited number of turbine test facilities (offshore, onshore and workshop tests).
Actions	• Support collective industry action to increase offshore test sites. • Raise awareness among enabling bodies of the value of onshore facilities in growing the local renewables industry.
Traffic light rating (see Section 3.1)	

3.7.1 RD&D and testing

Landscape

With a few exceptions, there has not been extensive engagement by the UK's academic community with the wind industry. However, the economic opportunities from offshore wind have been increasingly recognised by funding bodies and there has been significant investment from the Carbon Trust, the Energy Technologies Institute, DECC, and various subnational enabling bodies. These investments aim to maximise the economic benefit of offshore wind to the UK and, by engaging overseas manufacturers, they enhance the security of the UK component supply and hence the delivery of UK offshore wind.

A critical issue will be the time taken to carry out demonstration and verification of new technology. A number of developers identified the potential lack of proven turbines for the beginning of Round 3, which may create a short-term bottleneck.

Issues

Limited number of turbine test facilities (offshore, onshore and workshop tests). The Crown Estate has recognised the value of offshore technology demonstration sites, facilitating the development of four sites so far (see Table 3.7.1), of which two are led by Round 3 developers. In Section 3.3.1, we discuss the supply issues concerning the next generation of offshore turbines.

Our feedback from developers is that many recognise the need for increased offshore test site capacity, but there is less interest in supporting the development of such activity directly. There is also a strong recognition from many in the supply chain of the growing need for the development of onshore sites to test offshore wind turbines, as such sites offer significantly cheaper and more convenient solutions for verifying most aspects of turbine design than working offshore.

“Test sites are always interesting
– if easily accessible.”

WIND TURBINE MANUFACTURER

Table 3.7.1. Planned UK offshore wind demonstration sites.

Site	Turbines	Demonstration site developer	Status
Gunfleet Sands extension	2	DONG Energy Gunfleet Sands Demo (UK)	Agreement for lease
Blyth Offshore Wind Demonstration site	Up to 20	National Renewable Energy Centre (Narec)	Agreement for lease
Methil Offshore Wind Farm	2	2-B Energy	Exclusivity agreement
European Offshore Wind Deployment Centre	11	Aberdeen Offshore Wind (75% Vattenfall and 25% Aberdeen Renewable Energy Group)	Exclusivity agreement

Actions

Support collective industry action to increase offshore test sites. Test sites may not be economically attractive for individual companies, which could be addressed by a consortium approach. Further action to make additional demonstration site capacity available would be valuable, both onshore and offshore, as progress in this respect has been relatively slow.

Raise awareness among enabling bodies of the value of onshore facilities in growing the local renewables industry. Many potential inward investors have requested access to onshore demonstration sites for very large offshore turbines, often with a lead time less than that required to consent a new site.

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4. Methodology

The analysis used the following methodology:

- Initial industry engagement was based on a preliminary installation forecast and summary listing of key industry constraints. This formed the basis of confidential telephone discussions with key representatives in most developers active in the UK market. Factual input, company and personal views were received and presented back to interviewees in writing for refinement and approval for use.
- We then revised our forecast based on feedback received and engaged selectively with key supply chain players in order to assess in more detail the key areas of concern raised by project developers, thereby establishing a categorisation for each area of supply.
- We then used the installation forecast, information gathered and our experience of the structure of the supply chain and offshore wind construction projects in order to develop forecasts of spend and demand for a range of key components and services, offsetting spend and demand from the installation forecast to the year in which supply is required.
- For a number of areas of supply, such as foundations, subsea export cables and installation vessels, we used a project-by-project analysis in order to predict technology use and cost based on parameters such as water depth, distance from shore and anticipated wind turbine size.
- We assessed potential bottlenecks by listening to the views of different members of the supply chain, considering the existing supply base, perceived intent to invest and time from investment in new manufacturing capability to the point where there is sufficient market confidence to buy in quantity.
- BVG Associates is grateful to the many people who contributed through formal interviews and informal discussions.

Further feedback is always welcome.