Changing the Scale of Offshore Wind
Examining Mega-Projects in the United Kingdom
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1

Offshore wind ‘mega-projects’ in the United Kingdom
1.1 Market context: Offshore wind in the United Kingdom

Wind is one of the United Kingdom’s (UK) most plentiful renewable energy resources. Studies show that, as a nation, the UK has the most favourable conditions for offshore wind power generation in Europe and perhaps in the world. According to industry association RenewableUK (formerly the British Wind Energy Association), the electricity generation potential of UK offshore wind alone could amply exceed the country’s total electricity demand requirements. This plentiful source of clean and renewable energy is a key piece of the UK’s strategy to meet its ambitious climate change and renewable energy commitments. At the European Union (EU) level, the 2009 Renewable Energy Directive stipulates that 15 percent of the UK’s final energy consumption should come from renewable energy by 2020, up from 3 percent in 2010. In parallel, the current carbon budget under the UK Climate Change Act (CCA) of 2008 aims to reduce the country’s greenhouse gas (GHG) emissions by at least 34 percent by 2020 and by at least 80 percent by 2050 (on a 2010 baseline). The CCA is also geared to deliver the UK’s share of the emissions reduction targets adopted under the EU’s Emissions Trading Scheme directive (EU ETS). The ETS is the key instrument for achieving the EU’s proposed targets to the United Nations Framework Convention on Climate Change’s (UNFCCC) negotiations.

The UK government has adopted a series of policy measures to stimulate the progressive deployment of offshore wind which, alongside other renewable energies, is expected to play a crucial role in attaining these challenging objectives. To date, these policies have proven effective in attracting investment and supporting the sector’s growth, as evidenced by the rapidly increasing capacity and electricity production of offshore wind, as well as by the diversity of investors. Installed capacity of offshore wind turbines has more than doubled since 2008, reaching some 1.3 gigawatts (GW) in 2010, or about 1.5 percent of the UK’s total generation capacity, and placing the UK as the global leader in installed offshore wind plants. The 15 currently operational offshore wind farms, which have average load factors that are typically much higher than for onshore wind, produced about 1 percent of 2010 total electricity output in the UK (approximately 3 TWh). Notwithstanding, a steep increase in offshore wind capacity growth is still required if the renewable energy and emissions abatement targets are to be met.

A supportive regulatory framework

The Office for Renewable Energy Deployment (ORED) is the administrative body tasked with ensuring the attainment of the UK’s renewable energy targets. ORED’s activity relevant to offshore wind is focused on:

Providing financial support for renewables. In the summer of 2011, the UK government published the Electricity Market Reform (EMR) white paper (see sidebar on page 9). The EMR seeks to adopt a series of framework initiatives to provide long-term, comprehensive and targeted support for low-carbon generation and renewable technologies. Currently, the principal incentive supporting offshore wind development is the Renewables Obligation (RO, see sidebar on page 9), but other support mechanisms (such as the proposed feed-in-tariffs with contracts for difference) are expected to bring additional support.

Unblocking barriers to delivery. The second main component of ORED’s mission is to identify and address issues that affect the timely deployment of established renewable technologies including the planning system, supply chains and grid connection.

In addition to the RO and the planned elements of the EMR, the UK Renewable Energy Roadmap, published alongside the EMR white paper, lays down a set of supplementary policies, measures and support programmes to further stimulate the development of the offshore wind industry. In particular, these measures seek to remove a series of barriers that have been identified as limiting factors to the development of the offshore wind industry. These programmes include:

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Supporting innovation to reduce costs: The government will provide up to £30 million in 2011-2015 to reduce costs through technology development and demonstration. It will establish an offshore renewables Technology and Innovation Centre (TIC). A £25-million investment from the Energy Technologies Institute (ETI) will go to a drive-train test facility at the National Renewable Energy Centre (NaREC).

Developing the supply chain: Up to £60 million for the development of wind manufacturing facilities at ports will be provided by the government, as well as some £70 million from the Scottish government to strengthen port and manufacturing facilities for offshore wind turbines and components in Scotland.

Minimising investment risk: The government will complete the accelerated banding review of the RO, implement electricity market reform and put in place EMR-RO transition arrangements.

Accessing finance: Offshore wind will be a strong candidate for support from the Green Investment Bank (GIB). The UK government will work with developers and investors through the Offshore Wind Developers Forum to identify the investment capital required for offshore wind and whether further government action is appropriate. The government will take action to reduce investor uncertainty in relation to oil and gas clauses in offshore wind farm leases.

Ensuring cost-effective grid investment and connection: The Offshore Transmission Coordination Project review of incentives for coordination will be performed to ensure coordinated development of medium-term (Round 3) offshore transmission assets. The review will develop a long-term position on security requirements for grid connection.

Planning and consenting: Manage the potential impacts of offshore developments on other users of the sea and broader environmental considerations through publication of an Offshore Strategic Environmental Assessment. Identify and, where appropriate, manage potential delays to consenting decisions.
Outlook for offshore wind in the UK

The Renewable Energy Roadmap's 'Renewable Energy Strategy lead scenario' suggests that, by 2020, about 30 percent of electric power could come from renewable sources, compared to around 6.7 percent in 2010\textsuperscript{16}. Offshore wind will have a central role in delivering those ambitious objectives.

The 'central range' of estimates by the government indicates that some 18 GW of offshore wind power could be operational by 2020, growing to 40 GW by 2030 (see Figure 1). Separate from the 4.2 GW expected to be operational over the next 24 months or so (see Figure 2), achieving the 2020 target implies a compound growth rate of 20 percent/year. Assuming deployment of wind farms at that scale and using offshore turbines with a capacity of 5 MW, meeting the target would represent a demand of some 360 offshore wind turbines/year. This level of demand and deployment will have important implications and will require significant changes across component supply chains, logistics and services, as well as health, safety and environmental management.

Indeed, the rapid pace of required growth in UK offshore wind capacity and generation is prompting the development of what in this paper we are referring to as 'mega-projects'; that is, wind farms with capacities in excess of 800 MW—roughly the size of a utility-scale large coal- or natural gas-fired plant. The size and complexity of developing projects of this size offshore is similar to a small field development in the North Sea.

Offshore wind mega-projects were already on their way. The UK Crowne Estate, which is the landlord of the UK's seabed, has carried out three rounds of tenders for leasing the seabed for offshore wind projects\textsuperscript{17}. In Rounds 1 and 2, which respectively took place in 2001 and 2003, leases for some 8 GW of potential capacity were awarded to winning applicants. The average project size in Round 1 and Round 2 was, respectively, approximately 100 MW and approximately 400 MW.

In 2010, Round 3 was concluded, awarding winning applicants the lease of areas with a potential to install up to 32 GW of offshore wind power. In stark contrast to the two previous rounds, the average project size in Round 3 was approximately 1 GW. Construction has already begun for one of these mega-projects, and an additional 11 mega-projects are in the planning stages (see Section 1.3).

These mega-projects will have significant and diverse effects, not only across the wind industry's value chain in the UK and beyond, but also across the electricity and fuel value chains. This Accenture paper assesses and discusses the challenges of such mega-projects and their potential implications for the relevant players across the energy industry.

In this paper, we review the key challenges facing the offshore wind industry and explore potential solutions, including:

- Key bottleneck areas in the value chain such as the turbine supply chain and vessel contracting.
- Offshore infrastructure development and health, safety and environment (HSE).
- Grid integration and intermittency management.
- Other considerations and challenges, including access to finance, consenting and R&D programmes.

In our concluding remarks we look at some of the expected implications on wind and broader energy industry players such as:

- Utilities.
- Oil and gas companies.
- Turbine manufacturers.
- Oilfield service providers.
- Vessel contractors.
Figure 1. Deployment potential to 2020 for offshore wind in the UK.

Terawatt-hours (TWh)


Figure 2. Existing capacity and planned pipeline of offshore wind projects in the UK.

Megawatts (MW)

In July 2011, the UK government published the document, ‘Planning our electric future: a White Paper for secure, affordable and low-carbon electricity’. The document, now referred to as the Electricity Market Reform (EMR) white paper, sets out key measures to attract investment, reduce the impact on final prices, and create a secure mix of electricity sources including gas, new nuclear, renewables, and carbon capture and storage. Most of the main components of the EMR package will have a direct or indirect effect on offshore wind investments and operations and include:

- **A carbon price floor** to reduce investor uncertainty stemming from price volatility in the EU ETS by putting a fair and minimum price on carbon emissions and provide a stronger incentive to invest in low-carbon generation now.

- **A feed-in-tariff with contracts for difference** (FiT-CfD) to provide stable financial incentives to invest in all forms of low-carbon electricity generation.

- **An emissions performance standard** (EPS) set at 450 grams (g) carbon dioxide (450g CO\(_2\)/kilowatt-hour (kWh) to provide a clear regulatory signal on the amount of carbon new fossil-fuel power stations can emit.

- **A capacity mechanism**, for demand response as well as generation.

The government plans to legislate for the key elements of EMR in spring 2012, and for legislation to be implemented by the end of spring 2013, with a view for the first low-carbon projects to be supported under its provisions around 2014. The government’s 2012 budget confirmed ongoing support for these plans.

The main policy supporting UK offshore wind development and other renewables is the Renewables Obligation (RO), which came into force between 2002 (England, Scotland and Wales) and 2005 (Northern Ireland). The RO is an ‘obligation on electricity suppliers to source a specific and annually increasing proportion of electricity from eligible renewable sources or pay a penalty’.

The obligation side of the RO scheme is similar to the Renewable Portfolio Standards used in other markets such as the United States, effectively creating a monetary incentive for suppliers (through prospect of a penalty) to increase the share of renewable power in their supply portfolio.

The RO scheme also provides compliance flexibility and economic efficiency through the issuance and trade of Renewable Obligation Certificates (ROCs). The Office for Gas and Electricity Markets (Ofgem), the UK market regulator, administers ROCs to qualifying installations producing renewable power. These ROCs can then be sold by generators directly to electricity suppliers or traders, and can be traded separately from the physical electricity supply to which they relate. This has created a market for ROCs which, in addition to providing a monetary incentive to investors in renewable power via revenues from ROC sales, serves to deliver greater economic efficiency by leveraging the forces of supply, demand and competition in pricing the ROCs. ROC trading is administered by the Non-Fossil Purchase Agency (NFPA), which connects buyers and sellers of ROCs through electronic auctions (e-ROC).

Since 1 April 2009, the amount of electricity to be stated in a ROC has depended on the technology used to generate the electricity, a change to the original scheme that is referred to as ‘banded RO’. Prior to that date, one ROC was awarded for each megawatt-hour (MWh) of renewable electricity generated. With the introduction of banding, different generation technologies receive different numbers of ROCs depending on their costs and potential for large-scale deployment.
The obligation levels for 2010–2011 were 0.111 ROCs/MWh of electricity supplied to customers in England, Wales and Scotland, and 0.0427 ROCs/MWh of electricity supplied to customers in Northern Ireland21. In 2011–2012, the level of the obligation will increase to 0.124 ROCs/MWh supplied in England, Wales and Scotland, and 0.055 ROCs/MWh supplied in Northern Ireland.

Suppliers meet their obligations by presenting sufficient ROCs to Ofgem to cover their obligation. Where suppliers do not have sufficient ROCs to meet their obligation, they must pay an equivalent amount into a fund known as buy-out, the proceeds of which are paid back on a pro-rated basis to those suppliers that have presented ROCs, an additional incentive. The government policy intent in the 2010 amendment orders is that Great Britain suppliers will be subject to the RO until at least 31 March 2037, and those in Northern Ireland until at least 31 March 2033. The buy-out price for the 2011-2012 compliance period was set at £38.69 per ROC22.

Between 1 April 2009 and 31 March 2010, Ofgem issued 21.2 million ROCs (representing 20.3 GWh of renewable electricity generation)23. Between January and December 2011, the average price for ROCs sold via e-ROC auctions was £47.95/ROC, for 712,000 ROCs auctioned over the period24. This suggests an annual value of the electronic ROC market of some £34 million. The value of the full ROC market, assuming an annual issuance of some 24 million ROCs25 and a unit price of £48/ROC, would be about £1.15 billion.

ROC banding for different renewable generation technologies.

<table>
<thead>
<tr>
<th>Technology</th>
<th>ROC band</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshore wind</td>
<td>1.5 ROCs/MWh</td>
</tr>
<tr>
<td></td>
<td>2 ROCs/MWh for stations or capacity accredited between 01/Apr/2010 and 31/Mar/2014</td>
</tr>
<tr>
<td>Onshore wind</td>
<td>1 ROC/MWh</td>
</tr>
<tr>
<td>Wave and tidal</td>
<td>2 ROCs/MWh</td>
</tr>
<tr>
<td>Dedicated energy crops</td>
<td>2 ROCs/MWh</td>
</tr>
<tr>
<td>Advanced gasification and pyrolysis and anaerobic digestion</td>
<td>2 ROCs/MWh</td>
</tr>
<tr>
<td>Sewage gas receives</td>
<td>0.5 ROCs/MWh</td>
</tr>
<tr>
<td>Landfill gas</td>
<td>0.25 ROCs/MWh</td>
</tr>
</tbody>
</table>

1.2 Costs and timelines for offshore wind projects

At first glance, a wind turbine may appear as mechanically simpler than traditional electricity generation technologies; however, the development of an offshore wind farm is a technically complex, lengthy, risky and capital-intensive process. In fact, offshore wind is still an emerging technology whose competitiveness vis-à-vis traditional generation technologies such as gas- and coal-fired plants in the UK is, in part, made possible by government support schemes such as the RO. Without such support, commercial-scale investments in offshore wind would not materialise under the current energy market conditions.

One of the necessary conditions for offshore wind to become a sustainable, mature and competitive power generation technology (i.e., one that is commercially attractive without government support, relative to competing alternative generation technologies), is the need for investment costs to significantly decline. In a recent report, the European Wind Energy Association forecast that Europe may have some 40 GW of offshore wind by 2020. Such a deployment of offshore wind capacity would require a quite rapid investment and construction programme, moving from about 1GW installed/year in 2011 to more than 6 GW/year in 2020, and a cumulative investment of some £55 billion over that same period.

To attract the substantial investments required to deliver this scale of growth, the offshore wind industry will need to demonstrate a trend of increasing competitiveness relative to other power generation technologies. Indeed, implicit in EWEA’s forecasts and estimates is a declining investment cost per MW of installed offshore wind plant, which is illustrated in Figure 3. EWEA’s figures suggest that investment costs would have to decline over the next decade from the current £2.3 million/MW to £1.3 million/MW in 2020. This represents a 46 percent reduction in investment costs over the period, equivalent to a compound annual growth rate (CAGR) of −6 percent. Similar projected cost reductions for the UK have recently been published in a report commissioned by the Department for Energy and Climate Change (DECC).

A typical offshore wind project is composed of three phases: investment, operation and decommissioning (see Figure 4). Capital spend is greatest in the investment phase, which can account for up to 80 percent of total project funds. Of total capital expenditure (CAPEX), the turbine, its components and structure account for the majority of investment, requiring 50 to 80 percent of the total. Due to the nature of the offshore marine environment, the development and consenting component can absorb up to 10 percent of capital requirements, while the installation phase can require up to 15 percent of CAPEX.

The development, construction and operation of an offshore wind farm is a therefore a lengthy, risky and capital-intensive project. Important cost reductions across all stages of the investment and operations phases will be required to make offshore wind a technology that is competitive with other power generation alternatives. Cost reductions are thereby a necessary condition to achieve the UK’s ambitious offshore wind capacity targets.

Accenture believes that the emergence of mega-projects will be a significant force in helping deliver those required cost reductions. The remainder of this paper examines how mega-projects will transform the offshore industry through the demands it will place on key components of the value chain.
Figure 3. Planned capacity growth of offshore wind in Europe and expected evolution of investment costs.

<table>
<thead>
<tr>
<th>Year</th>
<th>Forecast new capacity build (MW)</th>
<th>Investment cost (million £/MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>1,000</td>
<td>1.5</td>
</tr>
<tr>
<td>2012</td>
<td>2,000</td>
<td>1.0</td>
</tr>
<tr>
<td>2013</td>
<td>3,000</td>
<td>0.5</td>
</tr>
<tr>
<td>2014</td>
<td>4,000</td>
<td>0.2</td>
</tr>
<tr>
<td>2015</td>
<td>5,000</td>
<td>0.1</td>
</tr>
<tr>
<td>2016</td>
<td>6,000</td>
<td>0.05</td>
</tr>
<tr>
<td>2017</td>
<td>7,000</td>
<td>0.025</td>
</tr>
<tr>
<td>2018</td>
<td>8,000</td>
<td>0.015</td>
</tr>
</tbody>
</table>


Figure 4. Offshore wind project life cycle.

Notes:
Timing based on installation of a 100-turbine, 300-MW wind farm in 25 metre water depth.
Cost percentages are rough averages of publicly available data.
CAPEX = capital expenditure; EOL = end of life; OPEX = operational expenditure.

Source: Accenture analysis.
Mega-projects as a key driver of competitiveness

According to UK government estimates in the Renewable Energy Roadmap, in 2010, the levelised energy cost of offshore wind was in a range between £149 and £191 per MWh. To make offshore wind competitive with unsubsidised power generation technologies such as combined cycle gas turbines, the levelised cost of offshore wind would have to decline to somewhere nearer to £100 per MWh. Achieving this reduction would necessitate a major cost savings of between 30 and 50 percent.

With this scale of cost-reduction requirements, even an industry-wide implementation of leading practices in today’s scale of offshore wind farms (100 to 300 MW) would not suffice to drive down costs to make offshore wind competitive with traditional power generation technologies. Research by IPA indicates that a majority share of large, complex capital projects carried out since 1993, such as large-scale power plants or offshore oil and gas platforms, have been unsuccessful or suffered from cost overruns. Accenture experience has shown that the implementation of leading practices in managing large capital projects can achieve cost reductions of up to 20 percent per billion dollars of capital. While substantial, such savings still fall short of the important reductions required to make offshore wind competitive: enter the quest for economies of scale through mega-projects.

Figures 5 and 6 show the main offshore wind projects worldwide and the trend towards mega-projects. Noteworthy is the fact that the bulk of mega-projects globally are expected to be constructed in the UK (more than 70 percent of the identified planned projects), making the country a pivotal geography for the successful development and deployment of this technology.

The capacity of mega-projects is significantly larger and, in many cases, an order of magnitude greater than any wind farm currently in operation. The emergence of such mega-projects brings about the potential to significantly drive down costs in offshore wind development. Indeed, there is ample proof in the energy industry that increasing project size is a substantial driver of cost reduction. This point has been shown in the development of nuclear plants, and of oil and liquefied natural gas (LNG) tanker vessel size and LNG liquefaction units, among others. By moving from the current project size to mega-projects, some examples of areas where economies of scale could be achieved are:

- Better risk sharing and more efficient contracting.
- More cost-effective geological surveys.
- Greater competition putting downward pressure on prices across parts of the value chain.
- Greater appetite for investing in optimising and integrating supply chains.
- Larger turbine size and next-generation technologies for substructures could jointly deliver lower installation costs, greater power output per unit of investment (greater energy capture) and lower operations cost.
- Faster and safer installation and operations could be facilitated by a larger fleet of bespoke and specialised vessels for offshore wind.
- More mature technologies and processes would perform with higher reliability, reducing operating costs and health and safety issues.

Figure 7 provides greater detail of candidate areas where the scale of mega-projects could impact components of the offshore wind project life cycle.
Figure 5. Evolution of offshore wind farm size: from projects to mega-projects.

Offshore wind farms – operational

Distance from shore (km)

Offshore wind farms – under construction

Distance from shore (km)

Offshore wind farms – planned

Distance from shore (km)

Source: Accenture analysis.
<table>
<thead>
<tr>
<th>Project name</th>
<th>Country</th>
<th>Number of turbines</th>
<th>Distance from shore (km)</th>
<th>Size (MW)</th>
<th>Mega-project?</th>
<th>Consortium members</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operational</strong></td>
<td></td>
<td></td>
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<td></td>
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<td>Thanet</td>
<td>UK</td>
<td>100</td>
<td>11</td>
<td>300</td>
<td>No</td>
<td>Vattenfall</td>
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<tr>
<td>Horns Rev II</td>
<td>Denmark</td>
<td>91</td>
<td>30</td>
<td>209</td>
<td>No</td>
<td>DONG</td>
</tr>
<tr>
<td>Rødsand II</td>
<td>Denmark</td>
<td>90</td>
<td>9</td>
<td>207</td>
<td>No</td>
<td>E.ON</td>
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<tr>
<td>Lynn and Inner Dowsing</td>
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<td>54</td>
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<td>194</td>
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<td>Centrica</td>
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<tr>
<td>Walney I</td>
<td>UK</td>
<td>51</td>
<td>14</td>
<td>184</td>
<td>No</td>
<td>DONG &amp; SSE</td>
</tr>
<tr>
<td><strong>Under construction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>London Array</td>
<td>UK</td>
<td>175</td>
<td>20</td>
<td>1,000</td>
<td>Yes</td>
<td>DONG, E.ON, Masdar</td>
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<td>Greater Gabbard</td>
<td>UK</td>
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<td>23</td>
<td>500</td>
<td>No</td>
<td>SSE, RWE npower</td>
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<td>BARD Offshore 1</td>
<td>Germany</td>
<td>80</td>
<td>90</td>
<td>400</td>
<td>No</td>
<td>Enovos, BARD Group</td>
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<td>Sheringham Shoal</td>
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<td>TBC</td>
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<td>Yes</td>
<td>Trillium Power Wind Corporation</td>
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<td>28</td>
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<td>Delta Nordsee 1</td>
<td>Germany</td>
<td>286</td>
<td>39</td>
<td>1,255</td>
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<td>Morevind</td>
<td>Norway</td>
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<td>TrønderEnergi Kraft AS</td>
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<td>Ireland</td>
<td>220</td>
<td>13</td>
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<td>Fred Olsen Renewables/ Treasury Holdings</td>
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<td>Idunn</td>
<td>Norway</td>
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<td>TBC</td>
<td>1,080</td>
<td>Yes</td>
<td>Vestavind Kraft AS</td>
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<td>Ægir</td>
<td>Norway</td>
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<td>Oceanwind AS</td>
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<td>Sarlige Nordsjøen</td>
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<td>TBC</td>
<td>1,000</td>
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<td>Lyse Produksjon AS</td>
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<td>China</td>
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<td>TBC</td>
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<td>985</td>
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<td>162</td>
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<td>985</td>
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<td>Beatrice 2</td>
<td>UK</td>
<td>184</td>
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<td>920</td>
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<tr>
<td>Inch cape</td>
<td>UK</td>
<td>180</td>
<td>22</td>
<td>905</td>
<td>Yes</td>
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<td>20.7</td>
<td>900</td>
<td>Yes</td>
<td>Eneco New Energy</td>
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</table>

Sources: Accenture and RenewableUK. Used with permission.
Figure 7. Evolution of offshore wind project life cycle and candidate areas of cost reduction.

<table>
<thead>
<tr>
<th>Development</th>
<th>Component manufacture</th>
<th>Installation</th>
<th>Operations/ maintenance</th>
<th>Decommissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbine manufacture</td>
<td>Support services</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**As is**
- Expensive seabed surveys
- Lengthy licensing
- Multiple contracts for development phase
- Limited risk sharing
- Atomised supply chains
- Lack of standardisation
- 5MW gearbox units
- Monopile and space frame substructures
- Many onshore technologies and practices transferred to offshore
- Nascent services sector
- Supply shortage
- Adapted vessels
- Bottlenecks in grid connection components
- Revenues from subsidies
- Source of intermittency – require costly firming and grid upgrades
- Nascent services sector
- HSE issues – high insurance costs
- Little experience of decommissioning
- Low recyclability of certain components
- High decommissioning costs

**To be**
- Efficient survey technology from oil and gas
- Streamlined licensing
- End-to-end contracting
- More balanced risk sharing
- Optimised supply chains
- Standardisation for components
- Double-digit MW direct drive and hybrid units
- Second-generation substructures using oil and gas industry technology
- Bespoke offshore technologies
- Mature services sector
- Bespoke vessels
- Adequate supply of all installation components
- Improved energy capture and reliability
- Compete with all generation technologies
- Behave as baseload, through storage and adequate grid integration with back-up capacity
- Mature services sector
- Limited HSE issues – reduced insurance costs
- Developed decommissioning sector
- EOL value for turbine components
- Good recyclability

Source: Accenture analysis.
Leading practices in capital projects management

As shown in the figure below, the management of large capital projects is composed of six key phases, and includes initial business strategy, licensing and permitting, design engineering, procurement, construction and commissioning, and operations.

Accenture experience has shown that the implementation of leading practices across each of these phases has the potential to unlock significant benefits by achieving savings and delivering efficiency and performance gains. The benefits, which can be up to 20 percent savings per £1 billion in capital spend and deliver up to 5 percent increases in operating margin, are achieved through:

- Process efficiency improvements.
- Greater assurance of configuration controls.
- Optimised sourcing and procurement strategies.
- Tight control of vendor execution and adherence to schedule.
- Increased availability of plants at operatorship handover.

Standard and leading practices in capital projects management and scope of benefits.

<table>
<thead>
<tr>
<th>Business strategy</th>
<th>Licensing and permitting</th>
<th>Design engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard practice</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strategy is defined on a project-by-project basis and not inclusive of EPC considerations</td>
<td>Permitting and licensing function largely made up of external contractors</td>
<td>EPC vendors own engineering processes, owner-operator performs scope approvals</td>
</tr>
<tr>
<td>Project risk measures not clearly defined and integrated into the overall capital allocation plan</td>
<td>Licensing documents managed on a project-by-project basis</td>
<td>Multiple vendors perform engineering activities for a single project</td>
</tr>
<tr>
<td>Short-term focus, less than five-year planning horizon</td>
<td>Loose integration of licensing change management processes with EPC vendors</td>
<td>Manually intensive processes to reconcile engineering deliverables</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Leading practice</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear strategy is defined and guides all project decisions</td>
<td>Internal staff with deep regulatory relationships make up organisation</td>
<td>The owner-operator has a defined information strategy embedded into contractual obligations</td>
</tr>
<tr>
<td>Strategy governs EPC decision-making processes</td>
<td>Licensing function builds an integrated schedule with regulatory agencies</td>
<td>Heavy use of a 3-D model to identify cross-vendor engineering discrepancies</td>
</tr>
<tr>
<td>Portfolio strategy where all projects are optimised</td>
<td>Licensing processes are tightly integrated with EPC vendors to reduce rework</td>
<td>Tight engineering change control processes in place to identify deltas between revisions and maximise impact on operational output</td>
</tr>
<tr>
<td>Project risk measures standardised for all projects</td>
<td>Reuse of content is embedded into the overall structure of the licensing deliverables</td>
<td>Use of information standards (ISO 15926) to drive data exchanges and collaboration</td>
</tr>
<tr>
<td>Longer-term focus, with multiple planning horizons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Typical benefits**

- Benefits are realised in subsequent project phases
- 15-25% savings in licensing costs, achieved through process efficiency improvements
- 2-5% savings per £1 billion in capital spend, achieved through greater assurance of configuration control associated with a design change

Source: Accenture analysis.
**Standard practice**

- Sourcing strategy is not inclusive of all projects within a capital portfolio
- Lack of transparency into sub-supplier relationships (EPC owns relationship with subs)
- Cost-driven approach to lowering up-front component costs, versus total cost of ownership for the asset
- PMO processes are established on a project basis, without an overall standard
- Lessons learned are not tracked and shared across projects or functions
- Tracking and payment of contractor claims against a specific contract or group of contracts is labor-intensive
- Asset start-up and initial operations heavily supported by engineering and EPC vendors
- Lack of information transparency results in frequent data requests to obtain key operational data
- Operations spends the first few years uncovering design and construction flaws

**Leading practice**

- Optimisation of procurement for critical items across a portfolio of capital projects
- Leverage sourcing strategies to reduce up-front costs and long-term spare part issues
- Assured design changes with equipment, constructability and assets are identified and managed early in the procurement process
- Systematic management of EPC vendor and sub-supplier relationships to optimise the value delivered
- Well-defined PMO structure and methodology, including processes, project controls and earned value metrics
- Automated tracking and payment of contractor claims using tools that feed cost data to the project schedule
- Integration of quality assurance and lessons learned processes to ensure continuous improvement across multiple projects
- Engineering data feeds training and start-up processes
- Engineering and EPC vendor support focused on providing future services, lowering long-term O&M costs
- Operations uncovers design and construction flaws during the training and procedure authoring process
- Information turnover has been performed prior to operations, enabling better maintenance efficiency
- Performance and trending data shared with key business partners

**Typical benefits**

- 5-8% savings per £1 billion in capital spend, achieved through execution of strategic sourcing and procurement strategies
- 3-6% savings per £1 billion in capital spend, achieved through tighter control of vendor execution and adherence to project schedule
- 5-8% savings per £1 billion in capital spend, achieved through execution of strategic sourcing and procurement strategies
- 2-5% increase in operating margin, due to the increased availability of plants operating at design output during initial years of operation
- 2-5% increase in operating margin, due to the increased availability of plants operating at design output during initial years of operation
Key challenges for offshore wind mega-projects

Along with the significant potential for producing clean electricity with offshore wind mega-projects comes the fact that some of the challenges are also magnified by their scale; overcoming these challenges will be key in delivering the imperative of cost reductions and better project economics. The scale, complexity and investment required for mega-projects mean that current supply chains, business models, processes and practices will have to change. There needs to be a line of sight towards lower development and operating costs and greater revenues or these projects will not be built. This section highlights what Accenture believes are the four biggest hurdles that the industry will have to surmount as mega-projects begin to emerge.
The global wind turbine market is currently oversupplied, as the general economic downturn, limited availability of capital, and high and volatile prices for raw materials have resulted in frozen projects and generally weaker demand. With incremental demand in Europe and the Americas being outpaced by that in China and other Asian economies, manufacturing is rapidly being transferred eastward, also hurting the supply side through market share losses for the industry in the Western economies.

While these short-term market conditions are driving a buyer’s market and re-composition of turbine supply, the long-term growth fundamentals remain: the global turbine supply chain will need to transform and ramp up drastically to support the development of 40 GW of offshore wind power capacity licensed by the UK Crown Estate, alongside similar levels of expected growth in other regions including the United States, China and continental Europe. Yet, ensuring cost-efficient growth and guaranteeing high quality under such demand levels could pose serious challenges.

The turbine supply chain is therefore a potential bottleneck. In its current state, the supply chains serving the nascent offshore wind industry possess a series of characteristics that need to evolve for mega-projects to become viable and attractive investments. Many of these characteristics are a direct consequence of the absence of a strong demand-side pull that incentivises R&D spend, cost reductions, and greater competition, cooperation, integration and specialisation. So, if the higher demand does begin to materialise, is there real potential for offshore wind turbine supply to transform and deliver savings?

Part of the answer lies in that much of the existing offshore turbine supply chain is set up to cater for the development of the smaller-scale, land-based wind farms—which today make up the bulk of wind turbine demand. As a consequence, offshore wind projects have to a large extent been employing technologies, processes and business models adapted from the onshore industry, rather than designed for the very different offshore marine construction and operations environment. The turbine supply chain needs to transform and, indeed, will be transformed, by the order of magnitude changes in turbine demand that mega-projects will bring about.

If all UK-planned offshore wind is to be built within the period of 2015 to 2022, the average rate of construction would be one turbine per day—significantly greater than the industry’s current production capacity.

Overview of the turbine supply chain

The names of the main elements of an offshore turbine are not dissimilar from those of its land-based counterparts although, for the reasons previously discussed, these are quite likely to evolve in time. Differences between the two types have and will continue to develop over the years with respect to turbine size, blade materials and performance, drive train and, especially with the expected emergence of double-digit megawatt units, towers and sub-structures. Also, the development of projects increasingly further from shore means that transmission technology will very likely shift from high voltage alternate current (HVAC) to high voltage direct current (HVDC) due to the lower losses over large distances from the latter technology.

The degree of vertical integration in the offshore wind turbine market is quite limited and the business models are varied. Most of the leading turbine manufacturers focus on the manufacture of turbines, blades and towers, outsourcing the remaining components. A few of the market participants are present in manufacturing generators and controllers, and just a couple produce drive trains as well. This panorama is likely to change with the emergence of mega-projects, which could prompt more integration across the value chain and possibly further down into the substructures (e.g., with a move towards floating substructures) and grid-connection segments.
Scope for better economics from the turbine supply chain

Achieving significant cost reductions and revenue improvements or having a clear line of sight to how these will be achieved in coming years is vital to the entire offshore wind industry. With the business cases for mega-projects currently so dependent on government support, the promise of better project economics is the crucial component to attract investments at the scale required to develop them.

The offshore turbine, its components and structure represent about 50 to 80 percent of offshore wind costs\(^4\) and a holistic approach must be taken to significantly reduce costs. Primary drivers for cost reduction and greater efficiency include bespoke offshore design, optimisation of manufacturing and improved logistics.

In addition to reducing the costs of an installed turbine, better economics in turbine operations will also be key. Scale, better design and new component technologies will increase energy capture. Reliability and predictive maintenance will be essential in managing offshore operation and maintenance costs—a majority of all offshore maintenance is unscheduled corrective maintenance. Performance, reliability and predictive maintenance all start with turbine design.

**Turbine components and technology**

Most of the technology currently being used in existing offshore wind farms is technology that has been adapted from the onshore industry, rather than technology designed specifically for offshore applications.

This technology is being increasingly challenged as wind farm projects tend to go further offshore where there are increased water depths and wind speeds. To maximize energy capture, turbine sizes are getting ever larger, 6 MW models are already commercially available. But bigger is not always better: greater size can create reliability and logistics issues, some of which can be partially offset by reducing the size and weight of some components—swapping gearboxes for direct drive units is one such example. On the other hand, some of the usual constraints of the onshore wind industry such as noise and visual impact can become less important in the offshore environment, providing opportunities for technology innovation.

There is a general consensus that significant technology development is still needed to shift project economics to attract investors. However, the technology departments of the leading turbine manufacturers still focus predominantly on onshore technology, as onshore wind still represents the lion’s share of the turbine market. This technology bottleneck is one of the key obstacles that needs to be overcome, and we believe will be, with the emergence of mega-projects.

Our research has found that better economics for project developers and operators may be delivered through technology improvements across three main areas: reducing capital costs through production streamlining of components, lower operating costs through increased reliability and predictive maintenance, and by increasing revenues through greater energy capture.

---

**Figure 8. Vertical integration of leading turbine manufacturers.**

<table>
<thead>
<tr>
<th>Turbines</th>
<th>Rotor blades</th>
<th>Drive train (gearboxes/direct)</th>
<th>Generators</th>
<th>Controllers</th>
<th>Towers</th>
<th>Substructures</th>
<th>Grid connection*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enercon</td>
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<td>Gamesa</td>
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<tr>
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<tr>
<td>Suzlon</td>
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<td>Vestas</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Presence in specific stage of turbine supply chain
*Direct drive drive-trains

*Grid connection: Infrastructure service to provide physical connection between wind farm and grid.

Source: Accenture analysis.
Figure 9 illustrates the turbine components where technological developments may improve project economics through lower costs or improved revenues.

**Logistics**
Installing an offshore wind farm requires the transport and handling of multiple components that are typically very large, very heavy, but also very fragile. As is the case regarding the technologies of the turbines themselves, the logistics of offshore wind turbines have been so far largely borrowed from the onshore wind industry, but also from oil and gas offshore operations, usually involving high costs and time constraints due to the limited supply of specialised vehicles and vessels. New technologies, processes and coastal locations that allow for the complete production of floating turbines at or near ports, or the efficient assembly of turbines at sea could deliver dramatic cost and time reductions.

**Cooperation and contracting**
The development of the turbine supply chain remains uncoordinated, with unbalanced risk sharing and fragmented, non-standardised contracting practices prevailing among key value chain actors including developers, suppliers and government.

On the one hand, developers generally agree that without pre-orders, the supply chain will not develop and production capacity is unlikely to expand. But pre-orders are costly and risky, meaning developers may choose to wait until an adequate and sustainable turbine supply chain is in place before the final investment decision. This approach would help reduce the risks associated with pre-orders of components that have substantial lead times. Indeed, lead times for turbines remain one of the longest in offshore wind procurement, often taking two years or more. Suppliers on the other hand, promote a different approach and look for joint commitments and gradual/parallel development of consent and engineering, manufacturing capacity, financial investment decision and ordering. The contrasting approaches to project development and the contractual practices currently in place create a supply crunch at the time of the final investment decision, when components are effectively ordered. Inevitably, the response from the supply chain is lagged, resulting in shortage and delays.

The industry therefore finds itself in a situation of stalemate, with the supply and demand sides of the supply chain each expecting its counterpart to undertake higher risk, investment and provide greater assurance in order to move the industry forward. Breaking this gridlock, and crucially, achieving greater integration and alignment of the supply- and demand-side business objectives will likely require greater communication and collaboration, innovative risk-sharing and standardisation in contracting approaches, and exploring and developing opportunities for supply chain rationalisation. Government and business services firms should investigate new ways to further facilitate and broker this enhanced level of cooperation (see next section on Regulation).
Figure 9. Wind turbine components and potential scope for cost and revenue improvement.

<table>
<thead>
<tr>
<th>Component</th>
<th>Lower capital costs through component production streamlining</th>
<th>Lower operational costs through increased reliability and predictive maintenance</th>
<th>Greater revenues through higher wind energy capture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blade technology</td>
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<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Improved structural design</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Improved aerodynamic design</td>
<td></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Standardisation of gearboxes</td>
<td>●</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Direct/hybrid drive transmission</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Lower-speed generators</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Second-generation substructures</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Greater use of HVDC connectivity</td>
<td></td>
<td></td>
<td>●</td>
</tr>
</tbody>
</table>

Source: Accenture analysis.
Case study

Forewind

Company overview

Forewind is an incorporated joint venture made up of four leading international energy companies (SSE, RWE, Statoil and Statkraft). In January 2010, Forewind was awarded the development rights for Dogger Bank, which is the largest planned offshore wind farm in the world.

In accordance with the development contract, Forewind is committed to carry out a work programme to prepare the projects for consent. Each of the partners is scheduled to invest some £40 million in implementing the work programme. Forewind is responsible for:

- Developing projects.
- Obtaining agreement for leases.
- Achieving all key consents.

Due to the very large size of the Dogger Bank area, any development has to be made in phases, with several projects comprising the project tranches of each phase. The objective is to achieve consent for the agreed target of 9 GW of installed capacity by 2020, although the zone has a total capacity of almost 13 GW, or around 10 percent of the UK’s projected electricity requirements.

The investment decision will be taken by late 2014, after which the wind farms would be developed and maintained by various constellations of the parent companies and any additional future partners.

Business challenges

Construction cost reductions and better risk sharing: key components to make the economics work

To develop and install the 9 GW of Forewind’s planned capacity, investments in the region of £40 billion will be required. According to Björn Ivar Bergemo, head of business management at Forewind, proving that the economics work will be a crucial element in attracting investments of that magnitude. If Forewind can manage to keep costs down and demonstrate a sound business case, the consortium will also be an attractive investment.

Keeping costs down is one of the key challenges faced by the offshore wind industry today, with the turbine supply chain and vessel contracting standing out as the main cost components of the capital expenditure phase. To remain competitive for future funding, the industry must prove it has line of sight to achieving profitability without support from the taxpayer. This poses a key question: How long will government support be realistically maintained if the cost of installing offshore turbines fails to reduce below the currently observed levels of £2 million to £3 million/MW?

Today, developers carry the majority of the risk in the early phase of development. Other key stakeholders in the sector, including electricity grid operators and the government, should take on a greater share of the construction risk to increase the attractiveness of the industry to more investors and developers. For this shift in risk-sharing to materialise, however, the industry must start to demonstrate a trend of improving its cost efficiency.

Reducing the costs of securing connectivity to the power grid

One of the most crucial issues for companies in the early development stage relates to the investment required to establish the necessary grid reinforcements that will secure adequate grid connection capacity for the planned maximum output of the offshore wind project.

At present, the government does not require grid reinforcements. Rather, reinforcements and grid connection take place through bilateral agreements between National Grid and developers such as Forewind. The developer must sign cancellation securities that are updated bi-annually. These cancellation securities represent large sums that are released and lost to the grid operator if the developer fails to fulfill its engagements. These sums increase as the date of commissioning approaches and, in the case of gigawatt-scale projects, billions of pounds have to be secured by the developer to ensure grid connectivity. These cancellation securities represent a large risk for developers, especially since these are important sums that need to be put on the table prior to investment decision.

Governmental bodies need to be more aligned to reduce risk in grid connection process. To make the industry sustainable, it is required to shift away from the current model where developers carry the entirety of the risk from grid connection cancellation securities.

Improving the health, safety and environment (HSE) performance

Health and safety risks in the offshore wind industry have proven to be very real and its health, safety and environmental (HSE) performance needs to improve. The industry in general is getting increasingly more focused on the health and safety issues, and Forewind aims at being an industry leader in this field.

Apart from surveys and metocean mast installation, early developers have very limited experience of the complex environment that is marine offshore operations. Substantial health and safety risks exist in the installation as well as in the operation and maintenance phases of a project, with the most severe risks stemming from access to and egress from the turbines. Both vessels and helicopters are part of construction and maintenance operations. The risk profile can be significantly reduced by minimising the number of required onsite visits through higher reliability of plant and kit.
Forewind will include several options for operation and maintenance strategy in the consent applications, leaving the final decision to the future site operator. Forewind believes that safe operations and maintenance are obtained by jointly managing technology, mindsets and people.

Environmental risks and issues are well covered by work performed for consent applications. These studies also represent an important cost element. The Environmental Impact Assessment is one of the key deliveries of the consent application and includes data gathering by vessel and airplane and thorough analysis. The environmental statement covers all environmental issues as well meaning that, for the future lead operator, health and safety will be relatively more important focus areas than environment.

According to Forewind’s health and safety manager, the offshore wind industry has much to learn from the oil and gas industry in regard to health and safety. Compared to the oil and gas industry there are, for example, obvious gaps in offshore wind regulation, perhaps due to the nascent nature of the offshore wind industry. Regulations are fundamental in establishing a cross-industry standard that serves to adequately mitigate health and safety risks. The offshore wind industry should leverage on the developed principles from oil and gas. For example, in the North Sea, knowledge sharing around leading practices and incidents within the industry has been very successful through the years and remains so today.

Risks are lower in the wind industry in the sense that the type of machinery, plants and components used to build and operate wind farms has technical characteristics that are unlikely to cause major catastrophes, such as spills or large-scale explosions. On the other hand, the risks linked to installation, operation and maintenance at large heights and/or in open waters are very similar and in some aspects greater (e.g., presence of fast-moving turbine blades for helicopter operations) than in the oil and gas industry. Knowledge sharing and transfer from the offshore energy industry would be very beneficial in improving health and safety performance in the offshore wind industry.

Developing a sustainable supply chain
If the UKI planned offshore wind capacity is to be built between 2015 and 2022 a construction rate of one turbine per day will be required. Today, the offshore wind turbine supply chain is far from being able to meet such demand levels.

Supply chain capacity must increase without the requirement of pre-orders. Carrying the full risk of securing sufficient component capacity and pre-orders prior to final investment decision puts a significant amount of pressure on developers. To benefit from the potential growth opportunities in this market, investment from suppliers will be a key element to building a sustainable supply chain.

Forewind believes that consent application could be made more flexible through the approval of various concepts that the lead operator could evaluate and select from, thereby increasing the scope of options with respect to technology and design. This would serve to stimulate competition, innovation and cost reduction by suppliers. However, such an approach would also have negative implications for the lead times of component manufacture as well as supply chain capacities.

Securing the right talent
In the initial development phase, competition for human resources with the oil and gas industry has been limited, and actually less than what was initially expected. Rather, the more important resource issues have been related to attracting the right talent to the industry as a whole, and having sufficient time to train staff.

Scalability as a key determinant of technology selection
Offshore wind turbine technology is evolving rapidly and it is anticipated that turbines with capacities up to 10 MW may be available within the timescales of the first Forewind projects on the Dogger Bank.

Forewind believes that the scalability of any given technology will be crucial and small players will be able to grow quickly, provided they have the right technology with the adequate scalability.

Key lessons learned
A green light for any gigawatt-scale project will be a game changer for the offshore wind industry. Projects with planned capacities in excess of 1 GW such as Forewind are of a completely different nature relative to the much smaller existing offshore wind projects. Forewind expects that mature manufacturers will step up and secure a sustainable supply chain or risk seeing investors and operators walk away. The current issues regarding turbine manufacture lead times are thus expected to be solved by key suppliers.

Technology choice is not as much of an issue as there are only a few suppliers who could support a gigawatt-scale project. However, new technologies will get folded in, probably through mergers and acquisitions (M&A).

Health and safety represent substantial issues for the industry and knowledge transfer from oil and gas and regulations are required, but environmental issues are of less concern as they are handled thoroughly within the consent application process.
2.2 Vessel contracting

A considerable share of the vessels contracted for offshore substructures and turbine installation have been adapted from the oil and gas industry. Vessels are used across all phases of the offshore campaign, but there is particularly high competition for those necessary during installation, including heavy lift vessels, pipe/cable-laying vessels and transportation vessels. There are approximately 675 vessels designed for the oil and gas industry, many of which are directly transferable to offshore wind. However, as oil and gas projects rebuild momentum and decommissioning in the North Sea continues, the offshore wind industry faces strong competition and is experiencing a shortage of vessels. Additionally, the requirements for offshore wind vessels have evolved to become more stringent and industry-specific to address the unique challenges posed by complicated access and egress. Accordingly, the supply shortage and changing requirements have led to the commissioning of dedicated installation vessels. More than 20 specialised installation vessels are projected to be deployed to the offshore wind market by 2013, which will likely put downward pressure on day rates and accelerate the retirement of less-qualified vessels. Developers currently face security of supply risks that drive the need for further investment.

Developers and vessel manufacturers acknowledge the need for vessels that are optimised for offshore wind farms; however, such high-spec vessels are complex and difficult to build, taking approximately two years to complete and requiring a significant investment, upward of £100 million. Many developers expect manufacturers to build capacity without confirmed contracts; however, investors are reluctant to commit capital without a guarantee of potential profits. This stalemate between developers and vessel suppliers, which is akin to the situation with turbine manufacturers discussed in Section 2.1, causes delays in new vessel availability, which ultimately affects project performance and profitability. Therefore, many developers are assuming the risk up front and confirming contracts before final investment decision and in the midst of funding challenges. If developers are unwilling to assume this risk, particularly when dealing with mega-projects, then governmental support might be necessary to avert cancellation of the project. The European Wind Energy Association (EWEA) is projecting that £1.7 billion investment in ships will be needed to provide for the predicted growth of offshore wind farms. Although specialised ships are being commissioned, it is unclear how many will actually materialise and whether or not they will satisfy market demand.

Funding challenges also present HSE issues related to vessel contracting. When early developers do not have enough funding to invest in new or high-quality vessels to conduct offshore surveys, and install metocean masts and wind buoys, health and safety issues may become more prevalent. Many offshore wind developers cannot afford the high day rates of top-end oil and gas vessels and likely cannot afford the expensive mobilisations to bring these vessels in from other regions when faced with supply constraints. Offshore construction day rates for high-end vessels can exceed £335,000/day and inter-region mobilisations are often in excess of £13 million/mobilisation. While these prices are within budget for large oil and gas projects, they are typically excessive for the smaller offshore wind project budgets. Therefore, offshore wind projects are often left with two options—utilize the few specifically designed offshore wind vessels available on the market or convert the older oil and gas vessels that are no longer active. Both options involve supply constraints in the tight market. Additionally, using older, cheaper vessels may increase HSE risks and, to some extent, environmental risks. Ultimately, for vessels, as in many other segments of the offshore wind industry, the uncertainty and lack of definitive funding is causing a supply constraint that may result in delayed project schedules. A common understanding of the future of the industry and its profitability is necessary for the vessel suppliers to make a dedicated commitment to the offshore wind market. Figure 10 presents some of the main companies supplying vessels to the offshore wind industry.
### Marine contractors

<table>
<thead>
<tr>
<th>Company</th>
<th>Country</th>
<th>Service description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GeoSea (part of DEME)</td>
<td>Belgium</td>
<td>Wind farm construction</td>
</tr>
<tr>
<td>Scaldis (part of DEME)</td>
<td>Belgium</td>
<td>Place foundation, transformers, install wind turbine</td>
</tr>
<tr>
<td>Seaway Heavy Lift</td>
<td>Cyprus</td>
<td>Wind farm installation</td>
</tr>
<tr>
<td>A2Sea</td>
<td>Denmark</td>
<td>Transport, foundation installation, turbine installation</td>
</tr>
<tr>
<td>Swire Blue Ocean</td>
<td>Denmark</td>
<td>Foundation and turbine installation</td>
</tr>
<tr>
<td>HGO Infrasea Solution</td>
<td>Belgium</td>
<td>Wind farm installation</td>
</tr>
<tr>
<td>HGO Infrasea Solution</td>
<td>Germany</td>
<td>Wind farm installation</td>
</tr>
<tr>
<td>BARD</td>
<td>Germany</td>
<td>Develop, manufacture and construct offshore wind farm</td>
</tr>
<tr>
<td>Hochtief</td>
<td>Germany</td>
<td>Offer foundation installation through Hochtief solution</td>
</tr>
<tr>
<td>Muhibbah marine</td>
<td>Germany</td>
<td>Wind farm installation</td>
</tr>
<tr>
<td>Ballast Nedam</td>
<td>Netherlands</td>
<td>Design and build wind farm</td>
</tr>
<tr>
<td>Heerema Fabrication Group</td>
<td>Netherlands</td>
<td>Engineering and fabrication of offshore wind farm</td>
</tr>
<tr>
<td>Jack up Barges BV</td>
<td>Netherlands</td>
<td>Installation of rotor, blades</td>
</tr>
<tr>
<td>Jumbo Shipping</td>
<td>Netherlands</td>
<td>Wind turbine transition piece installation</td>
</tr>
<tr>
<td>Smit</td>
<td>Netherlands</td>
<td>Heavy lift and transport turbine foundation</td>
</tr>
<tr>
<td>EIDE Marine Service</td>
<td>Norway</td>
<td>Offshore wind turbine installation</td>
</tr>
<tr>
<td>Fred Olsen Energy</td>
<td>Norway</td>
<td>Through its subsidiary Harland and Wolff to design and build offshore foundation, substation, install turbines</td>
</tr>
<tr>
<td>Inwind</td>
<td>Norway</td>
<td>Survey, transport and install turbine, foundation, substation</td>
</tr>
<tr>
<td>Master Marine</td>
<td>Norway</td>
<td>Wind farm installation</td>
</tr>
<tr>
<td>Fugro Seacore</td>
<td>UK</td>
<td>Site investigation, foundation installation</td>
</tr>
<tr>
<td>GOAH Offshore</td>
<td>UK</td>
<td>Transport and install turbine, foundation</td>
</tr>
<tr>
<td>MPI Offshore</td>
<td>UK</td>
<td>Install foundation, turbine transformer, array cabling, transport and project management</td>
</tr>
<tr>
<td>SeaEnergy</td>
<td>UK</td>
<td>Wind farm access, operations and maintenance services</td>
</tr>
<tr>
<td>Sea Jacks</td>
<td>UK</td>
<td>Wind farm installation</td>
</tr>
<tr>
<td>Subsea 7</td>
<td>UK</td>
<td>Cable installation, foundation and substation construction</td>
</tr>
</tbody>
</table>

### Cable installers

<table>
<thead>
<tr>
<th>Company</th>
<th>Country</th>
<th>Service description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT Offshore</td>
<td>Denmark</td>
<td>Subsea cable installation</td>
</tr>
<tr>
<td>NKT Cable</td>
<td>Denmark</td>
<td>Turnkey solution for wind farm including cable installation</td>
</tr>
<tr>
<td>Nexans</td>
<td>France</td>
<td>Turnkey solution for wind farm including cable installation</td>
</tr>
<tr>
<td>Technip</td>
<td>France</td>
<td>Subsea cable installation (Acquired SubOcean in 08/2011)</td>
</tr>
<tr>
<td>Siem Offshore Contractor</td>
<td>Germany</td>
<td>Submarine cable installation, repair and maintenance</td>
</tr>
<tr>
<td>Prysmian</td>
<td>Italy</td>
<td>Turnkey solution for wind farm including cable installation</td>
</tr>
<tr>
<td>Visser &amp; Smit</td>
<td>Netherlands</td>
<td>Leading power cable installation contractors in Europe</td>
</tr>
<tr>
<td>Aker Solution</td>
<td>Norway</td>
<td>Solution for subsea power distribution for offshore wind</td>
</tr>
<tr>
<td>ABB</td>
<td>Switzerland</td>
<td>Cable manufacturer and installer</td>
</tr>
<tr>
<td>Briggs Marine</td>
<td>UK</td>
<td>Turnkey solutions for subsea cable installations</td>
</tr>
<tr>
<td>Global Marine</td>
<td>UK</td>
<td>Provider of submarine cable installation, maintenance and related engineering services worldwide</td>
</tr>
<tr>
<td>Subsea 7</td>
<td>UK</td>
<td>Cable installation, foundation and substation construction</td>
</tr>
</tbody>
</table>

Company overview

SeaEnergy PLC is a public limited company, and its subsidiaries form an energy services group, headquartered in Aberdeen, Scotland. It has a heritage of combining oil and gas and renewables, and has operated as project developer and service provider in both sectors. The group is currently establishing an offshore energy services business, which aims to provide access and other services to the expanding offshore wind industry as well as to other offshore energy clients, and also holds a number of investments in oil and gas.

SeaEnergy will provide operations and maintenance services to offshore wind farms, and the vessels from which to provide these services. Its state-of-the-art vessels and other assets for offshore wind farm commissioning, operations and maintenance will help developers reduce costs and increase safety through:

- Integration of proven leading technologies.
- Co-location of access, accommodation and work functions.
- Reducing fleet numbers by using multipurpose vessels.
- Purpose design and build for support throughout the wind farm life cycle.
- 24/7 long-term deployment in the field.
- Minimising cycle time for safe efficient working at multiple sites.

Accenture interviewed John Aldersey-Williams (CEO) and Mike Comerford (technical director) from SeaEnergy PLC around the challenges and opportunities facing the offshore wind industry in the UK and elsewhere.

Business challenges

Offshore wind should embrace the lessons learned in other offshore technologies to develop its own solutions

The offshore wind industry is currently characterised by a series of traits that need to evolve for it to be successful at scale. These traits include appropriate build/install strategies, floating turbines, reducing cycle time, use of purpose-built assets, supply chain involvement and cultural issues.

Many of the existing practices and technologies being applied to offshore wind projects today are basically onshore wind solutions that have been 'marinised'. SeaEnergy recognises that new and bespoke turbine technologies, logistics and supply chains and operational attitudes are required for the large-scale deployment of offshore wind to be successful.

Alternative build/install strategies—lessons from oil and gas

Two options for turbine manufacture and construction represent the ends of a spectrum of strategic possibilities:

- Assemble turbines close to shore and ship fully assembled units: The experience in the oil and gas industry suggests this is the preferred option, given the complexity of construction planning and work in the marine environment, especially when multiple units are involved, as expensive and higher-risk offshore hours are minimised. Significant development in ports and bespoke vessels would be required to support this more efficient offshore operation. In addition, some development of turbine designs will be required to make them tolerant of the requirements of the integrated installation approach.

- Ship wind turbine sub-assemblies and assemble offshore: This option is less efficient, as it involves more risky and expensive offshore hours, but is how the industry is currently operating in most cases. Again, significant development in ports would be required, but this may be dispersed among a number of ports with each potentially specialising in limited aspects of the supply chain (e.g., cables, blades, towers, etc.). In this case, fewer bespoke vessels might be required, leading to a lower risk to vessel owners as vessels can be multipurpose and for developers as alternative vessels are available if required.

The selection of build strategy will be determined by the economics of alternatives, together with an assessment of the risks implicit in each possible approach.

Floating turbines

Floating turbines are likely to be an important aspect of the longer-term way forward. Installation requires fewer specialist vessels and less-dedicated equipment; consequently, logistics are simpler and the risks associated with these elements of project implementation may be reduced. Development of such technology would facilitate worldwide rollout of offshore wind as water depth is no longer a limitation.

Reducing cycle time – lessons from lean manufacture

Independently of the construction strategy, turbines need to be designed for offshore construction. The dispersed multiunit nature of wind farms means that minimising cycle time for installation and commissioning and operations and maintenance (O&M) is vital.
An efficient manufacturer such as a Japanese automaker would examine the manufacturing process and minimise the number of assembly steps. For this to happen in wind farms, an end-to-end design and construction process needs to be considered, bringing together manufacture, logistics, construction and operations and maintenance considerations into the design. The introduction of automated process for turbine and foundation assembly, and the standardisation of components would also enhance buildability and quality, reduce cost, errors and cycle time.

Right now, every supplier has their own design and there are few offshore-specific solutions. However, for investments in automation to happen, manufacturers require line of sight of long-term turbine demand.

**Cable installation – importance of purpose-built vessels**

Another issue is that there is frequently cable damage during installation, often because the cable installation vessels are not purpose designed. When transatlantic cables were being deployed, purpose-built cable ships were used and cable was manufactured and loaded directly onto these ships in an integrated way. If a similar approach was adopted for offshore wind, integrating manufacture, loading and installation of cables with purpose-built equipment, lower-cost and higher-reliability installations would result.

**Supply chain involvement**

All of the previously mentioned improvements require collaboration with and within the supply chain. The existing industry supply chain is not ideally configured for large offshore projects, and developing a well-functioning supply chain will require good international coordination. Important manufacturing facilities are already in place in Germany and Denmark, so there is potential to scale up capacity in locations there, where supply chain and shipping capability already exist, although the scale of the opportunity means that there is also potential for new, purpose-built and optimised manufacturing capacity to be built in the UK or elsewhere in Europe. In turn, this requires relationships to develop and improve, as well as maturity and incentives for quality across the supply chain. In particular, there is a need to build trust and longer-term commitment at both ends of the supply chain.

Utilities and developers need to shift focus from the cost/MW installed to the cost/MWh generated. Contracting practices will need to change. Longer-term relationships need to be established: some continental utilities have a practice to sacrifice short-term margins for longer-term returns, the industry could certainly do more of this.

A significant challenge for the offshore wind industry will be how to transfer the skills and capabilities developed in the oil and gas sector into the renewables sector. Companies such as SeaEnergy, with a heritage in both oil and gas and renewables, are well positioned to facilitate this transfer.

**Cultural barriers**

Industry culture is also a potential barrier, as evidenced by resistance from utilities and wind companies to embrace the offshore experience of oil and gas companies. Barriers need to be broken to build trust between manufacturers, developers and oil and gas companies.

**Using purpose-designed vessels to improve project performance**

Industry sources suggest that the chartering of installation vessels typically comprises about 2 percent of project capital expenditure. But the influence of the installation vessel performance on project outcomes is huge.

The use of purpose-designed vessels can deliver very significant schedule advantages, thereby more than offsetting its additional cost. With a purpose-designed vessel, initial CAPEX (capital expenditures) and day rates may be higher, but the likelihood of overruns will be lower and the project returns both higher and less subject to schedule risk. But the appetite for building highly specialised vessels critically depends on the availability of finance. This can lead vessel operators to ‘dilute’ their ideal bespoke design and/or incorporate features (which broaden the vessel’s capability but increase its cost and required day rate) in order to be able to secure finance.

To be able to move away from this model, developers need to better apply the difference between price and value and to encourage the development of a clear and secure pipeline of future work. There is a big difference between the price to deliver a project—determined by the cost of project equipment and/or the total cost per installed MW of capacity, and the value of that project, measured in terms of £/MWh of power generated over the project life cycle. At present, the emphasis is frequently on minimising the cost of individual project elements (such as installation vessel day rates), when a more holistic view focused on maximising the project life-cycle value would be better. It can be very expensive doing things the cheap way.

**Improving HSE**

High safety performance is achieved by being in control, just like good business is about being in control. This requires planning, resourcing, monitoring and executing according to plan. At the moment, safety in offshore wind is similar to how it was in the oil and gas industry in the 1970s—with an unclear and unintegrated safety regime and inadequate safety behaviours. HSE has to be the responsibility of the operator who formally becomes the duty holder, and has full responsibility for health and safety management and outcomes.

Another stumbling block is lack of clarity: it is not always clear who is regulating offshore wind. The industry as a whole needs to move from a ‘what can we get away with’ mode to a ‘what should we be doing’ mode. This is partly due to the lack of regulatory clarity. An integrated and clearly-defined HSE regime for offshore wind would be good for business. The North Sea oil and gas industry helped to develop and embraced the offshore installations (Safety Case) regulations. Safety Case
Regulations essentially boil down to one simple regulation: ‘avoid major accidents (such as hydrocarbon spills or fatalities) or face prosecution and almost inevitable legal penalties’. People understand that they are on the hook for the risks and set out to manage them. In offshore wind, there is really no need for a complete new set of regulations, just an application of safety case regulations for offshore wind. Currently, construction design management only applies to construction phase. Safety Case should be applicable to the entire wind farm life span.

**Regulations and incentives**

The fact that offshore wind is being developed suggests that the regulatory and incentive framework is working, but it could be improved. For example, ROCs under the Renewables Obligation are noncontractual credits, which makes financing difficult. This is especially true for companies with small balance sheets. Feed-in-tariffs would make financing much easier, as project revenues will be viewed by financiers as bankable.

The consenting process for offshore wind farms remains long and torturous and should be streamlined. The recent reorganisation of the marine management agencies has not so far helped, as the structural changes have not been matched with capacity, making them a slow regulatory body.

**Intermittency management**

The market should decide which choice is best for backing up the intermittency of offshore wind output. The grid and market players will have to learn to accommodate intermittency.

**Key lessons learned**

SeaEnergy believes the two main messages for the offshore wind industry are:

1. The industry needs to think about the right problems at the right scale. These include developing an adequate supply chain, changing contracting practices, embracing holistic HSE practice, and working with all actors across the value chain to produce better offshore-specific solutions.

2. The industry can learn from the experience of those industries that have had to deal with similar problems in the past. Candidate areas for skills and capability transfer include substructure technology, venturing, contracting and risk sharing, and HSE management.
2.3 Development and HSE: Leveraging the experience of offshore oil and gas

The open ocean is a challenging environment in which to gain experience. Successful operation offshore is highly dependent on the ability to execute projects on time, on budget and safely. However, the safe execution of projects is an area that has been a concern for the industry as it has expanded. With rapid growth comes the need for fast increases in experience and expertise. Yet acquiring experience requires time, something that, considering the planned ramp-up in capacity build, the offshore wind industry does not have too much of. Fortunately, many of the skills and safety practices necessary to operate offshore were developed through a long, arduous and costly process by the oil and gas industry over the last 40 plus years. Several years of lost-time incidents and heavy project cost overruns are experiences the offshore wind industry should do its best to avoid. The fast-tracked timeline to have 18 GW of offshore wind generation by 2020 does not grant developers much time to become a mature, safe and stable industry. Growing the industry from a small, government-subsidised effort into a large-scale, reliable source of renewable energy will require quick thinking and the adoption and transposition of valuable lessons learned from those that have been there before: the pioneers of offshore energy—oil and gas.

In recent years, the extensive project delays, cost overruns and higher HSE incident rates than in equivalent oil and gas fields quite clearly suggest that onshore wind experience is not directly transferrable offshore. The challenges presented by the North Sea’s difficult environment present a threat to the execution of on-time, on-budget and incident-free projects. While leading practice project management and increased experience will help with cost and schedule, developing a safe work environment is more difficult. Accenture research and interviews with industry executives suggests that the offshore wind industry has a performance gap when it comes to HSE-related incidents and fatalities. Comparing the track records of offshore wind with offshore oil and gas is not a fair contest. The modern-day oil and gas industry has millions of man-hours of experience, and thousands of lessons learned supporting its safety culture. The offshore wind industry has started to pay more attention to HSE as it hopes to grow into a healthy and mature industry. RenewableUK’s ‘Lessons Learned Database’, launched in 2006, is an example of how the industry has matured significantly over the past years and has helped to foster a collaborative work environment among offshore wind development companies. In addition, industry-specific HSE conferences focused on collaboration provide another example of how the offshore wind industry is looking to take successful initiatives from oil and gas and adapt them to close the experience and performance gap.

RenewableUK lists ‘construction’ and ‘offshore’ as two of the focus areas for improvement in HSE for the renewable energy industry noting that ‘a significant proportion of the incidents recorded occurred during the construction phase of wind farm developments’ and that ‘the experience of incidents offshore highlights the logistical complexity of remedial actions available to offshore wind industry in that environment’. However, further compounding the issue of inherent HSE risks in the industry is the significant capacity and skills shortage from offshore field development suppliers. As offshore wind projects become larger in size and more technically complex, the number of dedicated offshore wind suppliers capable of executing the work is becoming smaller.

Fortunately for the offshore wind industry and for many oilfield services (OFS) providers currently operating in a declining North Sea market, there is significant overlap between offshore operations in oil and gas and in wind. While the source of energy generation may not be the same, there exist many
similarities in the types of services required for project execution. Offshore wind projects will require service capabilities from third-party suppliers ranging from front-end engineering design through to installation, connection and commissioning. Many OFS providers have recognised this potential and have begun moving into offshore wind through merger and acquisition (M&A) activity, building their own internal renewables division, or a combination of the two.

Although there are suppliers specifically geared to handle the needs of the offshore wind industry, many of these niche contractors lack the experience or capacity to handle the growth in size and complexity of the Round 3 projects. These projects are forecast to include the installation of some 32 GW of new generation across nine different zones compared to the combined 8.2 GW in Round 1 and Round 2. Additionally, Round 3 projects are located in deeper and more complex environments, requiring a greater degree of technical expertise. It is this push further offshore into deeper waters and harsher sea conditions that has led project developers to look to OFS providers for their technical capability and previous project experience. Additionally, as projects grow in size and complexity, so do their costs. Round 3 projects are forecast to cost more than £1 billion, with some zones targeted to exceed £10 billion. In short, the significance of Round 3 is high: Round 3 offshore wind energy is targeted to deliver 25 percent of the UK’s total energy needs by 2020.

The shift towards increased spend on larger projects in more challenging environments, combined with decreasing North Sea assets, has drawn the attention of various sides of the oil and gas industry. Traditional suppliers, operators and entire cities have recognised the opportunity to capitalise on their own offshore experience and move into this new, rapidly growing and potentially lucrative market.

Oil and gas experience may represent the key partner required to take offshore wind to the next level of self-sufficient operations. In a 2011 survey conducted by Aberdeen’s Robert Gordon University and commissioned by Accenture, 36 companies, organisations and institutions involved in either offshore wind or offshore oil and gas operations were surveyed to better understand the potential for transferability of oil and gas experiences into offshore wind. The results of this survey show a significant industry trend of adopting offshore wind as a strong future revenue source. More than three-quarters of respondents said that oil and gas experience was transferrable to offshore wind. In addition, when questioned about project phases, the design, construction, operation and decommissioning phases all had more than 60 percent of respondents indicating a direct transferability of skills between the two industries. Offshore wind has the potential to significantly benefit from the declining asset base occurring in the North Sea, as the shift towards more technically challenging projects is requiring a step change in skills.

Players taking note of the growing offshore wind market are not confined to OFS providers. The city of Aberdeen has embraced the transformation of its offshore industry from hydrocarbon exploration to wind generation, and has taken steps to ensure it is at the forefront of development. Since 2001, the Aberdeen Renewable Energy Group (AREG) has been active in encouraging the development of renewable energy projects. AREG is an incorporated company of more than 160 members, and has been working for more than 10 years to ensure Aberdeen plays a major role in its shift from being a hydrocarbon energy centre to a renewable energy centre.

AREG and its joint venture partners, Technip and Vattenfall, have been working towards the development of the European Offshore Wind Deployment Centre (EOWDC), to be located in Aberdeen Bay. Using its existing position as a leader in marine engineering, Aberdeen hopes the EOWDC will produce substantial benefits for offshore wind development leading to cost reduction and risk mitigation through reliability and capability testing. Additionally, OFS providers have begun to penetrate the market not only through direct translation of current capabilities, but also through innovative partnerships with project developers. Both Technip and Subsea 7 have signed Memoranda of Understanding (MOUs) with major utilities in Europe (Technip with the Spanish utility Iberdrola, and Subsea 7 with Scottish and Southern Energy (SSE)).

These partnerships are strategic efforts to bring together skills from the two main industries that compose offshore wind—i.e., onshore wind and offshore oil and gas. By utilising each partner’s respective skills, these alliances seek to “develop offshore wind projects in the most cost-effective and safe manner.”

If all parties involved get their way, the experience and knowledge learned from more than 40 years of energy production in the North Sea will play a strong role in shaping the future for offshore wind.
Case Study

Offshore wind: A perspective from oilfield services companies

Oilfield services, also known as engineering, procurement, construction, maintenance (EPCM), services or turnkey contracting, are a global industry that has several decades of experience of designing, constructing and operating in the difficult offshore marine environment. It is no surprise then that many of these companies are expanding into the offshore wind sector, given the scope for transferable experience and capabilities.

Examples of oilfield services and EPCM companies entering the offshore wind industry

Accenture surveyed publicly available information about global oilfield services companies as well as some of the key players operating in the North Sea to assess their involvement in the offshore wind industry. This review confirms that oilfield services companies are growing or looking to grow their offerings to the nascent offshore wind industry, especially in Europe. Following is a nonexhaustive list of examples of how oilfield services companies are increasingly looking to offshore wind as an area of growth.

Technip

In August 2011, Technip officially launched its offshore wind business, adding a fourth domain to its core business. The new business carries out operational installation and cable installation. As part of this new business, Technip have already undertaken several new initiatives:

- Acquired all of the assets of Subocean Group, boosting Technip's cable installation capabilities. Technip acquired almost 300 staff, some land-based assets and also significant ongoing contracts and contracts in backlog, growing its scope in offshore wind.
- Headquartered its European offshore wind business in Aberdeen, which will be used as an engineering centre of excellence to support UK and European offshore wind projects. The centre of excellence project is in partnership with Vattenfall and AREG (Aberdeen Renewable Energy Group), which is proposing the installation of up to 11 new generation offshore wind turbines.
- Signed a memorandum of understanding with Iberdrola (offshore wind business based in Glasgow) to develop farms off the French west coast.
- Installed one of the world’s first full-scale offshore floating wind turbines, ‘Hywind’ for Statoil, building and installing in Finland the world’s first gravity-based, ice-resistant foundation.
- Launched the Vertwind project, an association between Technip, Nénuphar, Converteam and EDF Energies Nouvelles to test a preindustrial prototype of a vertical-axis offshore floating wind turbine.

Subsea 7

- Subsea7 has a dedicated renewables energy business that provides project management, engineering and construction services to the offshore renewables industry1.
- In 2011, it created an alliance with SSE Renewables Developments2, the renewables arm of UK utility Scottish and Southern Energy (SSE). The two companies and other partners will work to develop and execute offshore wind developments—a potential portfolio of projects generating more than 5,500 MW of electricity from offshore UK wind farms. Subsea 7’s work scope involves all marine operations and integrated installation of the total offshore infrastructure including, turbines, offshore substation, foundations and cabling.

Neptune

Neptune serves clients in the renewable energy industry with customised fabrication solutions across the areas of construction design, general engineering and welding services. Neptune’s Aberdeen-based offshore division, from which it services clients in the North Sea and European markets, bills itself as ‘the industry leader for the development of marine renewable energy projects in the areas of wave and tidal systems and offshore wind projects’3.

Fluor

Fluor offers services for renewable energy projects that range from conceptual design to final completion, with renewable energy project development experience including engineering, procurement, construction, plant technology integration, program management, operations and maintenance, and commissioning4. Fluor provided engineering, procurement, and construction (EPC) services to Greater Gabbard Offshore Winds Limited for a 500-MW offshore wind farm off the Suffolk coast of the United Kingdom, which when complete, will be the world’s largest offshore wind farm5.
Petrofac

Petrofac is developing its capability to offer services into the European offshore wind sector. Following the acquisition of renewables sector technical specialist TNEI, Petrofac’s CEO said: ‘Petrofac intends to build a position in the renewable energy sector and our existing technical consulting, offshore engineering, project management and operational skills provide a strong base from which to enter this rapidly developing market. The addition of TNEI’s technical capabilities enhances Petrofac’s ability to serve the wind renewables sector.’6

Petrofac has worked with Tennet to deliver planning and engineering support, followed by maintenance and support services in the German North Sea.7 Petrofac has worked with Tennet throughout the development and pre-operations of the BorWin alpha platform, initially providing operations planning support, including training requirements and health, safety and environment directives. Following Petrofac’s initial planning and engineering support, the company was subsequently awarded a “maintenance and support services contract by ABB for the BorWin Alpha Platform including the provision of the offshore installation managers and commissioning engineers.”8

Saipem

Saipem Engineering and Construction has stated that part of its growth strategy is to excel in selected diversified businesses, including offshore wind.9

Business challenges for the offshore wind industry

Accenture interviewed an executive from the oilfield services industry, who pointed out that many of his industry’s capabilities are not yet being fully or even partially leveraged by offshore wind developers, and commented on the main business challenges facing the industry.

Competition for resources with the oil and gas industry

Offshore wind is a less mature industry than offshore oil and gas and with less financial backing, yet it needs to compete with oil and gas in order to conduct operations. Specifically, offshore wind projects are competing with oil and gas projects to attract the same types of engineers, project managers, vessels and suppliers. Oil and gas is a lucrative and well-practised industry, so to some, it is a more attractive opportunity. In contrast, there is less work, less funding and more risks involved in offshore wind, making it difficult to allure new suppliers or workers.

Contracting

Contracting approaches need to mature in order to drive offshore wind forward. In oil and gas, there are fairly standard contracting templates for types of work that are then modified on a case-by-case basis. This means that the scope and activity negotiation does not start from scratch with every project and that the industry has a common contracting language. In contrast, this does not exist in offshore wind making contracting, already a time-intensive and expensive exercise, even more costly than it needs to be. Every contract has to be built from scratch. In addition, offshore wind clients (typically utilities) have different legacy contracting practices. In oil and gas, the concept of a single project manager contractor (PMC) is common, while utilities have historically broken up projects into multiple components with different suppliers tendering for each. In the context of offshore wind, this practice fragments the supply chain, does not necessarily reduce overall project costs and increases risks. It also leads to a situation where it is often the lowest cost supplier for that piece that wins the bid versus the most qualified supplier that will reduce overall project costs. Uncoordinated delivery of project components presents a challenge in the offshore environment, where the value of supply chain interdependencies is exacerbated as a result of the high per-day vessel costs.

The treatment of risk, particularly weather risk, in contracting is another area where the offshore wind industry could incorporate learnings from its oil and gas counterparts. In oil and gas, risks such as weather or other installation risks are shared between the oilfield service provider and the oil company. The preference of utilities seems to be for the oilfield service provider to bear all of the risk. Without large insurance provisions, this is unlikely to be possible.

Growth and investment timing

In offshore wind, it is difficult to forecast future work. In considering the potential acquisition of a new vessel for offshore installation, a contractor faces high costs (a new vessel is likely to cost €250 million), and uncertainty (vessel may not have the necessary capabilities, e.g., to reach a depth of below 50 metres). Companies may then choose to wait until they win an order to decide what type of vessel to purchase; conversely, not having the vessel reduces the chances of winning an order.

Delivering cost reductions

As a developing industry, offshore wind needs to find significant savings across the value chain, perhaps as much as 50 percent. Turbine manufacture makes up about 40 to 45 percent of the cost of installation and the manufacturers have a way to go in reducing costs. Cost reduction in this stage can come from R&D and new innovations in design, manufacturing, build, and installation processes focused on the offshore environment and then tailored to the geographies. With more R&D, the designs will become cheaper to manufacture and the turbine size/output capacity ratio will improve. Much of the risk (and therefore costs) involved with offshore wind operations involve heavy lifting. As the technology improves, the materials should get lighter, making them cheaper to lift while the lifting operations should also become more efficient with practice.
Just like the turbine manufacturer and installation, oilfield services companies’ costs are likely to come down as they gain more experience in the industry and continue to innovate. The industry will likely move from piled offshore wind structure into floating structures. This will be another way to keep costs down, but will take time to develop the necessary innovations in technology.

Oilfield services companies provide similar services in offshore wind and offshore oil and gas. They typically incur similar operating costs for both industries and so charge similar prices, which are driven by operating costs. Longer term, there will be process and scale benefits—for example, from bulk purchases for large projects—but otherwise the cost of manpower, the engineers, will remain the same and will be impacted by what oil and gas is willing to offer.

The high costs to develop projects and manage offshore wind operations are likely to remain a significant challenge. The industry knows costs need to come down. Turbine costs need to come down but so do other areas of the supply chain. R&D teams are likely to find cheaper and more efficient methods for capturing offshore wind energy, but this will require up-front investment to develop the new technologies and the time to test them out. The competition from offshore oil and gas development makes offshore wind seem relatively expensive by comparison. With time, there may come a point of equilibrium, where oil and gas becomes more expensive and offshore wind becomes cheaper. Until then, developers will be competing for services and resources with the oil and gas majors and will need to fight to keep costs down.

HSE

While guidelines exist, there are limited health, safety & environment (HSE) regulations or reporting structures and this lack of HSE guidelines causes significant problems for offshore wind industry. There is a high fatality level and a poor industry record. The high fatality level will dissuade some from involving themselves in the industry. Furthermore, the lack of HSE regulations often results in the cheapest (and sometimes least safe) supplier seeming to propose the most attractive option. Putting in new HSE regulations will make the industry safer, but will be more expensive to operate. This added expense may force out smaller players that cannot afford to operate in this manner and, consequently, advantaging the larger players. This consolidation and maturing of the supply market is something that we have seen in other industries; for example, it is also happening now in onshore shale gas in the United States, where stricter environmental regulation is forcing out some smaller operators.

Despite the financial burden, HSE must be regulated in order to make the industry sustainable. Some industry executives believe that HSE should be managed by a government body, but not Ofgem, as the typical utility operation is far removed from the offshore environment. Offshore oil and gas experts should be used to share the leading practices in health and safety into the offshore wind industry. With time and experience, clearer HSE requirements can be established for offshore wind.

Summary

In summary, oilfield services companies are critical in the development of UK offshore wind. They bring decades of experience in safely building, operating and maintaining large structures offshore. In addition to the critical engineering resources, it is important that the oil and gas experience in HSE, project management, risk management and contracting be leveraged as far as possible. Offshore wind has to find a way to structurally reduce costs by about half, and line of sight of how this will happen has to be clearer in the next five years and cost reductions achieved during the build-out in the next 10 years. If not, developers likely will not invest.
2.4 Grid integration of offshore wind

The intermittent nature of wind generation means that integration into an electricity grid and associated market that values predictability is a critical step towards widespread wind energy deployment. Offshore wind speeds are stronger and more stable than on land, making offshore wind generation potentially easier to integrate into the generation mix than onshore wind. However, despite this advantage, offshore wind is still relatively unpredictable and integration will require so-called ‘back-up’ or ‘firming’ capacity that serves to even out the otherwise intermittent supply to the grid.

How wind is currently integrated

At present, back-up capacity for intermittent renewable power generation is provided by the generation fleet. The grid operator adjusts the output of the fleet to balance renewable supply variations using the operating reserve, in the same way it adjusts to changes in consumer demand or ‘load’ throughout the day. This reserve includes both base-load plants, which provide spinning reserve, and cycling and peaking plants, which can come online and ramp up rapidly to provide supplemental reserve capacity as needed.

Typically, base-load plants are large-scale hydro, nuclear, coal and combined-cycle gas turbine (CCGT) units, which are designed to efficiently generate hundreds or thousands of megawatts at a constant, optimum output level. In the UK, natural gas is the dominant base-load source, providing 47 percent of total electricity generation in 2010 compared to 28 percent for coal and 16 percent for nuclear. This dominance of gas is due to a significant build-out of natural gas capacity over the past two decades as North Sea gas discoveries, declining coal production and emissions regulations shifted support from coal to gas.

In recent years, the combination of electricity market liberalisation and widespread deployment of renewables has led to significantly less predictability in how much power an individual plant will be called upon to generate at any given time. This, in turn, has increased the amount of cycling a plant has to perform. The majority of plants were designed and built more than a decade ago, and they were built to minimise capital costs and optimise efficiency for a stable, maximum output at the expense of their ability to ramp up and down. The cycling of such existing base-load plants is costly as they have, by design, low ramp-up and ramp-down speeds and perform suboptimally at levels different from base-load output. Requiring them to be flexible increases plant maintenance requirements, deteriorates fuel efficiency and thereby produces higher emissions per kWh relative to normal base-load operation.

In addition to base-load generation, peaking plants provide additional back-up capacity, particularly during high-load daytime hours. Peaking plants are normally simple- or open-cycle gas turbines or diesel generators, which are able to switch on, and ramp up and down quickly to match supply and demand fluctuations. Fast-response peaking plants are typically better able to cycle to balance the large fluctuations in wind output than base-load units. However, peaking plants are also the least fuel-efficient plants in the generation fleet, and this lower efficiency means higher variable costs and higher emissions intensities.

To improve the effectiveness of offshore wind deployment, the status quo must be improved to include capacity better suited for backing up the intermittent wind output. Such capacity is likely to come from more flexible back-up capacity (particularly natural gas and hydro-electric power where available), and in the long term may include new energy storage technologies and demand response systems.
Improving the flexibility of back-up generation

As the grid’s requirements from the generation fleet change, utilities and power plant developers are adapting to support these needs. New power plants are increasingly built with flexibility as a key focus, including flexibility of fuels and of generation output. Through improvements in turbines, heat exchangers and input materials, plants are better able to adjust rapidly. For example, the latest coal and gas power plants installed by one of the leading German utilities are able to ramp up and down more than three times faster than older generation plants. In the UK, this trend could be less pronounced given the existing abundance of gas generation. Nonetheless, DECC forecasts the closure of approximately 11 GW of coal- and oil-fired capacity by 2016 and another 6 GW of nuclear plants. These capacity shutdowns will require the construction of significant new capacity to minimise the risk of a crunch point after 2015, the majority of which is likely to come from natural gas-fired units.

Increasing CCGT use will involve building new grid capacity and should also include retrofitting existing CCGT plant capacity to improve flexibility in locations where the economics are appropriate. Gas turbine and power plant manufacturers, such as Siemens and GE, are working to make CCGT plants more flexible, while retaining high efficiency during base-load operation. This development includes both new plant designs, such as GE’s FlexEfficiency™ 50 CC Power Plant that is marketed as a renewables back-up plant, and also upgrades to existing CCGT plants as proposed by Siemens. With more flexible designs, these plants can become base-load generators and also primary providers of the cycling capacity needed to support wind back-up.

Recent simple-cycle gas turbine models are also becoming increasingly energy efficient, rivalling existing base-load generation. For example, the latest 200 MW plus models can ramp up to 75 percent of their capacity in 10 minutes, and offer up to 38.5 percent efficiency in simple cycle operation, comparable with conventional coal plants. These units provide an efficient method of backing up fluctuations in renewable output, complementing the spinning reserve and rapid cycling of flexible base-load. While these models represent the cutting edge of gas turbine technology, the older peaking capacity on most grids does not provide such high efficiencies and its scheduling for renewables back-up does negatively impact the overall grid efficiency. For this reason, the deployment of new peaking capacity and flexible CCGT capacity should occur in tandem with renewables deployment to minimise operating costs as well as emissions.
Ability to cycle
Natural gas plants are easier to cycle than coal plants due to greater simplicity in controlling fuel supply and greater responsiveness of the direct combustion gas turbine systems compared to coal or biomass boiler-to-steam turbine systems. New CCGT plants can ramp up at 38 MW/minute, compared to 27 MW/minute for new coal plants. This greater ramp rate enables gas-fired units to vary output more quickly and with less wear on the system components, making them technically and economically superior for adjusting fluctuations in wind. Nuclear plants have an even greater ramp-up rate (63 MW/min), but given their low marginal cost and zero emissions output, generators prefer to dispatch them as base-load.

Security of supply
Recent increases in estimates of natural gas reserves and the ongoing expansion of the global liquefied natural gas (LNG) market have led to increased stability in global gas supplies and lower long-term gas price forecasts. This new paradigm of lower-cost gas has been driven by improvements in unconventional gas extraction (hydraulic-fracturing technologies for extracting shale gas), which are increasing the size of economically recoverable reserves worldwide. These new reserves are combining with a wave of LNG investment that was triggered by the high gas prices of the mid-2000s. New LNG production capacity is coming online from previously untapped gas reserves and new regasification capacity is also available in Europe and Asia, increasing the liquidity and supply diversity of LNG markets.

CO₂ emissions
Natural gas produces lower emissions of CO₂ and other pollutants than coal in power generation. This lower production is in part due to the lower carbon content in natural gas than that of coal, and in part because natural gas plants are generally more efficient than coal plants in converting fuel to electric power.

Natural gas as the current technology of choice for back-up of intermittent generation
To provide economic security to developers of flexible capacity, the government or grid operators should provide market systems to ensure such plants receive priority as back-up for renewables due to their greater efficiencies and cycling speeds relative to existing base-load capacity. A price on carbon is the most economically efficient way of providing incentives to develop more efficient and flexible plants. Other market-based policy instruments, such as a capacity market, could also be used to foster investment in high-flexibility back-up capacity. As described in the DECC’s Electricity Market Reform white paper, the UK government is currently assessing potential capacity mechanisms to ensure the provision of sufficient back-up capacity to support renewable growth. Any capacity market should provide sufficient potential economic returns for investments in flexibility as part of both new-build and retrofit projects.

Wind farms as schedulable plant: bespoke back-up capacity

In some locations, renewable energy developers are co-locating highly flexible, gas-fired power plants alongside intermittent renewable sources to allow the site to bid into electricity markets as a single, schedulable power plant. Although building 100 percent back-up capacity coverage would be too onerous for a multi-gigawatt offshore wind project, partnering with purpose-built, co-located back-up capacity would be valuable as a means of mitigating volatility of intermittency input into the grid, and for reducing the amount of cycling required by less efficient base-load and peaking units on the grid. Moreover, such partnering could allow for the use of predictive wind systems and data sharing between wind farm and back-up turbine operators to optimise the planning and dispatch of back-up capacity.

As opposed to the previously described capacity market systems, such specialized capacity development is a more direct approach to ensuring sufficient back-up capacity. This targeted mechanism provides a simpler approach and is easier to create and implement, but risks commitment to suboptimal providers and would also inhibit further innovation in back-up technologies once back-up capacity is established. The DECC has indicated a preference for a non-market approach, in which a central body would be responsible for owning and maintaining a strategic reserve as a set capacity margin, although capacity markets and reliability markets are still currently under assessment.

**Hydro-electric power**

Although natural gas is a prime candidate for wind back-up, hydro-electric generation is technically the most effective complement to renewable generation currently available. Hydro-electric power can be rapidly cycled, has zero operating emissions and has no loss of energy efficiency in the cycling process. Norway, a major player in future offshore wind deployment, is also home to 28 GW of hydro-electric capacity and is therefore in an enviable position as it integrates offshore wind. While hydro-electric power is technically attractive, its role as a major source of renewables back-up is limited by the number of suitable locations for its deployment. Some regions, such as Norway and Canada, are blessed with significant hydro-electric capacity. Elsewhere, however, deployment locations for large-scale, hydro-electric power are limited in most other geographies. In the United States and Western Europe, most potential hydro-electric locations have already been developed, leaving limited scope for additional growth to match widespread renewable deployment.

**Future technologies**

While natural gas and hydroelectric power are the best technologies currently available, both have limitations in moving to a carbon-free, energy-secure future. The technical ideal would be to have fully flexible capacity to efficiently store renewable electricity whenever there are surplus generation spillovers and to release this stored energy when in demand, thereby smoothing out the supply profile. Such storage could take place at the grid or local level and could be complemented by automated demand-response technologies, which adjust consumption of power by consumers to increase or decrease electricity consumption as output availability fluctuates. While such technologies offer significant promise, both are still emerging technologies and are unlikely to offer widespread renewable-back-up support in the near term.

Research into utility-scale storage technologies such as batteries, flywheels and compressed gas has occurred for decades and is seeing resurgence in investment due to the new growth in renewables and major breakthroughs in battery technologies from consumer electronics. The key challenges for grid storage technologies are to provide sufficient round-trip efficiencies to make storage of power economically attractive, with enough durability to allow the systems to operate on utility-industry timescales (decades rather than years), and to be scalable from a cost and resource perspective. At present, no technologies (outside of pumped-storage hydro) are close to overcoming these performance challenges.
barriers. A small number of pilot projects are beginning to test technologies, such as A123’s onshore wind back-up projects in China and Hawaii\textsuperscript{60}, but such pilots are still too small for commercial application. This research is still many years from delivering technologies that are durable and scalable enough to be a major source of back-up. 

Demand response is a novel method of managing renewables intermittency. Currently, demand response is primarily used as a means of peak shaving, allowing utilities to ask larger customers, or demand-response aggregators, to reduce their consumption during times of peak total electricity demand to reduce pressure on the grid\textsuperscript{61}. At present, demand response is a manual process with communication made person-to-person and power consumption adjustments performed manually. In the future, however, as building energy management systems are automated, appliances and equipment are built with ‘smart’ capabilities, and ‘smart grids’ are rolled out, there is an opportunity to build significant automated demand response capacity into the system. In this scenario, nonessential loads such as air conditioning and lighting could be adjusted by a building’s power control centre, industrial facilities could rapidly manage power to nonessential processes and, if electric vehicles achieve sufficient scale, there is the potential to control the power flow rates of electric vehicle charging stations to manage real-time consumption. Eventually, the grid could even allow two-way electricity flow to and from vehicle batteries as a means of nodal storage as previously described.

Although demand response offers significant potential, the half-lives of buildings are measured in decades, meaning deployment of enough buildings and factories with centralised building control and energy-efficiency technologies will take decades to achieve significant scale. In the decades until such technologies reach useful capacity, natural gas and hydro-electric power will provide the optimum means of cleanly, efficiently and economically integrating offshore wind capacity. However, in the future, these multiple systems could provide significant intermittency balancing opportunities.
Other considerations and challenges

Access to finance

Mega-projects are capital-intensive investments, and channelling the tens of billions of pounds required to develop the UK’s plans for offshore wind capacity will be a major challenge. Yet there is potential for improving access to capital for these large investments.

In addition to government support via the Green Investment Bank, the financial aspects of an offshore mega-project that could improve the accessibility to capital and a reduction in insurance costs include:

- Demonstrating a sound business case – Securing finance requires the demonstration of a solid business case. The financial community must be shown line of sight towards making offshore wind a technology that is competitive with traditional power generation technologies, given realistic scenarios on the evolution of key commercial drivers such as electricity and fuel prices, carbon prices and regulations, as well as government subsidies and other types of support.

- Diligence in assessment and management of construction, operating, financial, regulatory and other risks – financiers are typically conservative and place a high value on measuring risk. A systematic, comprehensive, transparent and objective assessment and presentation of risks along the construction and operation chains of offshore wind farms, and a plan to address them, would increase the likelihood of securing finance.

- Making a case for securitization and other structured finance instruments – Asset Backed Securities and other forms of debt pooling, whether to public or private investors, could be used to attract additional capital to finance offshore wind, but given the limited track record of offshore wind projects, this is very likely to require some type of government backing and support.

- Structuring project contracting, development and finance to match risk appetite of targeted sources of finance – the risk / return appetites of different sources of finance such as investment banks, infrastructure funds, insurance funds, pension funds, and private equity vary widely. Project developers and operators should carefully explore and consider tailoring their project to make it attractive to specific sources of finance.

Consenting and regulations

The UK government’s efforts to overcome development hurdles such as the streamlining of the consent application and environmental assessment processes are generally appreciated in the market, but there are still concerns in the supply chain. The government appears to be helpful in making minor adjustments, but commitment in addressing the needed fundamental changes is still perceived to be lacking.

There is a clear need for a more active coordinating government: failure to deliver in any one area (grid infrastructure, installation vessels or turbine manufacturers) will jeopardise the important investments made in many other elements of the supply chain. The planned 40 GW offshore wind development in the North Sea presents a significant opportunity for the development of UK industry. There is a risk that this opportunity will be missed if the government retains its position of being agnostic to the manufacturing location. That risk can be minimized by increasing support and fostering supply and demand side cooperation for the development of an adequate supply chain.
Regulations and clarity are also lacking in the HSE domain as well as in REACH (Registration, Evaluation, Authorisation and Restriction of Chemical substances in the EU) requirements. Offshore wind-specific HSE regulations in particular can promote the improvement of the industry’s security track record, thereby serving to reduce insurance costs.

Public R&D programmes

As part of its significant push for offshore wind, the UK government is dedicating important amounts of public funds for innovation in offshore wind turbine technology. The UK Renewable Energy Roadmap mentions R&D support from several organisations including the Carbon Trust, the Energy Technologies Institute and the Department of Energy and Climate Change. At the European level, the European Wind Technology Platform has been set up for the coordination of national activities, and dedicated FP7 joint calls have been established to investigate potential multiple uses of offshore sites. Developers, suppliers and operators should explore ways to leverage this support and collaborate to advance technology improvement until the market develops sufficiently to warrant larger-scale private R&D programmes.
Conclusions
Offshore wind is a promising and abundant source of clean and renewable energy. The developments in the UK, with multiple projects in excess of 800 MW being either built or planned thanks to a comprehensive framework of support from the government, are positioning this technology to compete with today’s utility-scale coal and gas plants. Yet to become truly competitive (i.e., absent government support) with traditional electricity-generation technologies, the development costs of offshore wind projects need to decline by nearly one-half, from today’s £2.3 million/MW to around £1.3 million/MW, and overall project economics need to improve. Accenture believes such mega-projects will change offshore wind economics by pursuing scale efficiencies, implementing leading practices in development and operations, and transforming the supply chain.

With total installed capacity of 3,917 MW globally, offshore wind power represents today only 0.08 percent of the world’s total installed power capacity. However, the UK is challenging this marginal market to scale significantly with 13 mega-projects likely to be built in the next two decades, which together would amount to more than 37,125 MW. Outside the UK, there are only 11 projects planned with capacities exceeding 800 MW. Moreover, other countries typically have less than two or three megaprojects. This means that the future potential for offshore wind will largely be determined by what happens in the UK market. Success or failure there will determine whether offshore wind will remain as a source of niche incremental capacity supported by government subsidies or whether it will contribute to a significant proportion of the electricity generation mix.

It is in the UK that current cost structures and operating models will be challenged first.

In this paper, we highlighted a series of key challenges that we see in developing projects of this scale, including:

- The supply chains of turbines and the vessel contracting industry, which are not currently adapted to support the volume, scale and specifications of the planned projects and where greater cooperation between the supply and demand sides of the value chain appears to hold the key to success.
- The need for offshore wind to improve HSE performance in development and operations over a relatively short timeline, primarily by leveraging lessons learned, capabilities and practices from the mature offshore oil and gas industry.
- The imperative to optimise and complement offshore wind output with other sources of generation to minimise the issues associated with intermittent power generation at large scale.

Undoubtedly, there are other important challenges here in detail, such as securing access to finance, but Accenture’s view is that the aforementioned issues are the showstoppers that are truly unique to offshore wind mega-projects.

In addition to effectively addressing the challenges highlighted in this paper, Accenture believes that to be successful, the offshore wind industry needs to have:

- The players required to develop the industry—i.e., the project developers (whether they are utilities, oil companies or consortia), the oilfield services and marine contracting industries, the turbine and component manufacturers, and the grid company—all aligned in the scale, the timelines, the understanding of each others’ business imperatives, and in the need to have a competitive cost structure for offshore wind.
- Greater maturity in its approach to working with the regulators, project planning and development, risk management, and HSE as well as with other actors in the offshore wind industry.
- Full implementation of leading practices in large capital project management and contracting.
- Flexible and low-cost infrastructure and operating models to cater for the requirements of consortia and changes in ownership and operatorship.
- A simple and straightforward regulatory framework to improve HSE performance.
- A more holistic and end-to-end understanding of the challenges and opportunities, necessary to develop the right capabilities, resources, and technologies to develop and operate in the marine environment.
Implications for key players

Overcoming the barriers and developing the capabilities to be successful in the strategic offshore wind industry will mean different things for the players across the value chain. The sectors coming together to deliver offshore wind—utilities, oilfield services, upstream oil and gas, vessel providers and turbine manufacturers—have different roles, legacy characteristics and capabilities. This section briefly reviews what these implications may be for the different players in offshore wind.

Utilities

Utilities will likely play a variety of roles in offshore wind mega-projects, from developers, to consortium members and operators. To be successful, utilities should:

- Determine and understand the role that offshore wind will play, whether directly or indirectly, in their generation portfolios.
- Understand the assets and skills needed to develop these projects and how to acquire them; e.g., capability development, acquisitions, joint ventures and service providers.
- Improve project management and engineering skills to deliver the structural cost reduction the industry requires.
- Acknowledge the lessons learned in other industries, oil and gas in particular, and develop the means to transfer that knowledge.
- Develop innovative contract structures to better share risk and adequately allocate incentives across the supply chain; e.g., shift business rationale from a cost/MW installed to a cost/MWh generated; move away from atomised contracting to Engineering, Procurement and Construction (turnkey) approaches.
- Identify and implement the appropriate operating models for consortia with oil and gas companies and other nonutilities partners.
- Understand the need and define a strategy for long-term technology R&D investment; e.g., in peak management, demand response and energy storage.
- Define and implement strategies for intermittency management; e.g., bundle with flexible capacity or manage it via the grid.
- Embrace the need for simple, firm, offshore wind-specific HSE regulations.
Engage with turbine manufacturers, vessel contractors, oilfield services providers and other industry stakeholders to develop a point of view about line of sight of cost reductions, to be socialised with industry and broader stakeholders (finance in particular).

**Oil and gas companies**

Oil and gas companies are the only companies really experienced in building and operating installations offshore of this scale. This offshore construction and operations experience gives them the potential to be key players in the offshore wind mega-project value chain. In addition, they also have natural gas assets. Natural gas will be the most important complementary fuel source to offshore wind. In the UK, some companies such as Statoil and Repsol have begun to lead the way by partnering with utilities and other players to develop offshore wind projects. Oil and gas companies that want to enter the offshore wind industry should:

- Leverage their offshore project management, development, construction, operations and HSE experience; e.g., acknowledge the need for knowledge transfer to offshore wind developers and operators.
- Determine how (e.g., technologies, operating models, contracting) natural gas could most effectively be leveraged by the offshore wind industry.
- Determine their appetite for partnering.
- Help developers in embracing an offshore wind-specific HSE framework.

**Turbine manufacturers**

Turbine manufacturers remain a key piece of the puzzle, and will likely hold back the reengineering, retooling and scaling of their operations, investments and capabilities until there is a clear line of sight to firm, long-term demand for offshore wind turbines. To be successful in supplying this market, they should:

- Explore new partnering models with project developers to secure future demand and reduce risk.
- Recognise that given the radically different logistics and operations in the marine environment, technologies will have to be designed with an end-to-end perspective, requiring greater inclusion of manufacturing location, logistics and maintenance considerations in the design.
- Acknowledge the need for cross-border cooperation between supplying countries and demanding countries to develop the most efficient, scalable supply chain.
- Explore and develop innovative ways to fund R&D for standardised components and offshore wind-specific turbines and technologies, including through partnering with all actors across the value chain.
- Engage with project developers, vessel contractors, oilfield services providers and other industry stakeholders to develop a point of view about line of sight of cost reductions, to be socialised with industry and broader stakeholders (e.g., finance).

**Oilfield services providers**

Oilfield services providers will also play a pivotal role, serving as catalysts for cost reductions in construction, operations and logistics. They should:

- Continue fostering innovative partnerships with developers and other organisations to pursue technology breakthroughs, reduce cost and share risk.
- Help developers in embracing an offshore wind-specific HSE framework.
- Explore opportunities for expansion into offshore wind through M&A to increase capability and quickly gain specific offshore wind expertise.
- Leverage their valuable experience working in the offshore oil and gas industry to expedite the development of the offshore wind industry by sharing lessons learned with offshore wind project developers and vessel contractors.
- Share lessons learned across the industry with other service providers.

**Vessel contractors**

Vessel contractors' activities fall on the project critical path and perform a major activity in the project life cycle. They should:

- Pursue long-term strategic agreements and commitments with developers to enable more secure financing for manufacturing new vessels.
- Explore options for maximising vessel utilisation across wind project developers as well as across industries (e.g., tidal/wave energy, oil and gas projects).
- Collaborate more closely with turbine designers and project developers to improve installation vessel design for offshore wind-specific projects.
- Identify vessel traits that maximise vessel suitability to offshore wind and, where applicable, modify existing vessels.
<table>
<thead>
<tr>
<th>Term/acronym</th>
<th>Definition or description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREG</td>
<td>Aberdeen Renewable Energy Group</td>
</tr>
<tr>
<td>Base-load plants</td>
<td>Large-scale hydro, nuclear, coal and combined-cycle gas turbine power plants that run during peak and off-peak hours</td>
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<tr>
<td>CAPEX</td>
<td>Capital expenditure</td>
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<tr>
<td>CCA</td>
<td>Climate Change Act (UK)</td>
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<tr>
<td>CCGT</td>
<td>Combined-cycle gas turbine</td>
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<tr>
<td>DECC</td>
<td>Department of Energy and Climate Change (UK)</td>
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<tr>
<td>EMR</td>
<td>Electricity Market Reform (UK)</td>
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<tr>
<td>EOWCD</td>
<td>European Offshore Wind Deployment Centre</td>
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<tr>
<td>EPS</td>
<td>Emissions Performance Standard</td>
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<tr>
<td>e-ROC</td>
<td>Electronic Auction of Renewable Obligation Certificate (UK)</td>
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<tr>
<td>ETI</td>
<td>Energy Technology Institute</td>
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<td>ETS</td>
<td>Emission Trading Scheme</td>
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<td>EU</td>
<td>European Union</td>
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<tr>
<td>EWEA</td>
<td>European Wind Energy Association</td>
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<tr>
<td>FIT-CFD</td>
<td>Feed-in-tariff with contracts for difference</td>
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<tr>
<td>GHG</td>
<td>Greenhouse gas</td>
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<td>GIB</td>
<td>Green Investment Bank (UK)</td>
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<tr>
<td>GW</td>
<td>Gigawatt</td>
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<tr>
<td>HSE</td>
<td>Health, safety and environment</td>
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<tr>
<td>HVAC</td>
<td>High voltage alternate current</td>
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<tr>
<td>HVDC</td>
<td>High voltage direct current</td>
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<tr>
<td>IPA</td>
<td>Independent Project Analysis</td>
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<tr>
<td>LNG</td>
<td>Liquefied natural gas</td>
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<tr>
<td>M&amp;A</td>
<td>Merger and acquisition</td>
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<tr>
<td>Mega-project</td>
<td>Offshore wind project with a capacity of 800 MW or more</td>
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<tr>
<td>MOU</td>
<td>Memorandum of understanding</td>
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<td>MW</td>
<td>Megawatt</td>
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<td>MWh</td>
<td>Megawatt-hour</td>
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<tr>
<td>NaREC</td>
<td>National Renewable Energy Centre</td>
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<tr>
<td>NFPA</td>
<td>Non-fossil purchase agency</td>
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<tr>
<td>O&amp;M</td>
<td>Operation and maintenance</td>
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<tr>
<td>Ofgem</td>
<td>Office for Gas and Electricity Markets (UK)</td>
</tr>
<tr>
<td>OFS</td>
<td>Oilfield services</td>
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<tr>
<td>ORED</td>
<td>UK Office for Renewable Energy Development</td>
</tr>
<tr>
<td>Peaking plant</td>
<td>Simple- or open-cycle gas turbines or diesel generators used during peak hours</td>
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<tr>
<td>REACH</td>
<td>Registration, Evaluation, Authorization, and Restriction of Chemical substances in EU</td>
</tr>
<tr>
<td>RO</td>
<td>Renewable Obligation (UK)</td>
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<tr>
<td>ROC</td>
<td>Renewable Obligation Certificate (UK)</td>
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<tr>
<td>TIC</td>
<td>Technology and Innovation Centre</td>
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<tr>
<td>TWh</td>
<td>Terrawatt-hour</td>
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<tr>
<td>UK Crown Estate</td>
<td>The entity managing licensing of the UK seabed for offshore wind power capacity</td>
</tr>
<tr>
<td>UNFCCC</td>
<td>United Nations Framework Convention on Climate Change</td>
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</table>
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Reference
For a map of offshore wind speed in Europe, see The World of Wind Atlases – Europe Section, www.windatlas.dk.

1

Approximately 1,000 terawatt-hours (TWh)/year by some estimates.

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22

Calculating the Level of the Renewables Obligation, UK Department of Energy and Climate Change, www.decc.gov.uk.

23


20


21

As previously noted, we define mega-projects as offshore wind projects with a capacity of 800 MW or more.

33

Ibid.

11

Ibid.

12

The mission of the GIB will be to provide financial solutions to accelerate private sector investment in the green economy developing new energy sources and developing carbon capture technology.

13

The Offshore Wind Developers Forum was established by the Crown Estate with the purpose to bring together Government and industry to find solutions to barriers that have the potential to impede the viability and deliverability of offshore wind, www.thecrownestate.co.uk.

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30

A measure allowing comparisons of investment and operations costs for different generation technologies.

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32


34

An increase in fuel, carbon and electricity prices would improve the competitiveness of offshore wind projects, all other things remaining equal.

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37

Accenture estimate from total offshore build in 2009 on RenewableUK website (www.bwea.com/statistics/2009.asp) and total number of deaths in offshore wind and large onshore turbines in RenewableUK Annual Health and Safety Report 2010 Used with permission.

38


39

Ibid.

40


43 Accenture-commissioned research undertaken by Audu, M. Jinadu, B., Mugisha, A., and Olusoga, A., MBA research students from Robert Gordon University.


46 Ibid.


48 C. le Pair & K. de Groot, ‘The impact of wind generated electricity on fossil fuel consumption’, www.clepair.net/windefficiency.html. A Dutch study calculated that for a grid with 5 percent of generation from renewables, if cycling of thermal plants to provide backup for intermittent plant output leads to an efficiency loss of only 2.5 percent across the grid, it would negate the fuel reduction initially created by the renewable generation. This assertion sounds alarmist; nonetheless, as intermittent renewables form a larger share of total generation, this effect is accentuated and minimising efficiency losses from firming capacity is increasingly important to maintaining the value of renewable deployment.


50 On a direct fuel comparison, combustion of natural gas produces roughly 55 percent of the CO$_2$ emissions/million btu of coal; add to this the higher average efficiencies of natural gas plants (approximately 55 percent) compared to coal plants (approximately 39 percent) and natural gas can produce as little as 40 percent of the CO$_2$ emissions/kWh that would be produced by a coal plant.


56 Accenture analysis based on data from EWEA and Enerdata (global energy and CO$_2$ data).


60 These agreements are often known as ‘interruptible contracts’.

61 Accenture analysis based on data from EWEA and Enerdata (global energy and CO$_2$ data).
About Accenture

Accenture is a global management consulting, technology services and outsourcing company, with approximately 261,000 people serving clients in more than 120 countries. Combining unparalleled experience, comprehensive capabilities across all industries and business functions, and extensive research on the world’s most successful companies, Accenture collaborates with clients to help them become high-performance businesses and governments. The company generated net revenues of US$27.9 billion for the fiscal year ended Aug. 31, 2012. Its home page is www.accenture.com.