UK Offshore Wind: Opportunity, Costs & Financing

November 2011

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The UK possesses some of the richest offshore wind renewable energy resources in the world with Round 3 offshore wind capacity factors expected to be over 40%. There is currently an installed capacity of ~1.5 GW and in total, under leases conducted to date (Rounds 1, 2, 3, Round 2 extension and Scottish Territorial Waters zones), ~54 GW of potential capacity has been awarded by The Crown Estate for development. The Government has made clear its commitment to offshore wind and in its 2011 Renewable Roadmap sets out an ambition to achieve 18 GW of installed offshore wind capacity by 2020.

Based on an average current cost for Round 3 projects of £3 million/MW the 18 GW ambition would imply an investment of ~£54 billion by 2020. However, the Committee on Climate Change (the independent body to advise the UK Government) cautions that only 13 GW of offshore wind capacity would be installed by 2020 at current costs, implying investment of £39 billion. Thus, a critical objective for the sector is to drive down CAPEX costs. In this respect the Government has initiated a Task Force setting out a cost reduction plan to reduce the levelized cost of electricity (LCOE) from £149-£191/MWh currently to £100/MWh by 2020, to enable the build-out of 18 GW of offshore wind. As an example, we calculate that costs would need to average to around the Department of Energy and Climate Change (DECC) low-end 2015 estimates of ~£1.9 m/MW for Round 2 offshore wind, and £2.3 m/MW for Round 3 offshore wind to bring the overall cost down to ~£39 billion for 18 GW installed.

Even if costs are reduced there will still be the need for billions of pounds of investment in the sector out to 2020 and the challenge will be attracting the levels of necessary finance in the pre-construction and construction phases where risks are highest. Looking at who might be the significant sources, pre-construction equity finance will need to flow from private sources such as PE firms and hedge funds in the form of common equity. Historically utilities have financed the construction and operational phases of offshore wind projects via their balance sheets, however the scale of capital required necessitates additional sources of debt and equity.

We see a key role for the Green Investment Bank (GIB) in providing debt and equity at the construction and operational stages of projects and a role for the European Investment Bank (EIB) in debt finance at both stages. We still expect that commercial banks will act as a private source of debt finance at both the construction and operational phases and utilities as providers of construction debt and equity. Pension funds and insurance companies will play an increasing role in the operational stage of debt and equity finance.

Regulatory support is crucial to support finance and must exhibit ‘TLC’ – Transparency, Longevity and Certainty. The UK is bound by the EU Renewable Directive to source 15% of its energy from renewable sources by 2020, or face infringement proceedings. The Government is thus incentivized to meet this target, although specific binding technology-based targets do not exist.

The market incentive to develop offshore wind is currently the Renewable Obligation (RO), obligating electricity suppliers to source an increasing proportion of their power from renewable sources. The obligation is met by buying Renewable Obligation Certificates (ROCs), generating ROCs by building renewable capacity or paying a buyout price for a ROC. This
buyout price is effectively a floor price and operates much like a tariff, helping to explain why the RO scheme is currently working.

As part of the Government’s Electricity Market Reform (EMR) process offshore wind projects will no longer be supported by the Renewable Obligation from 2017. Instead they will be supported by a Feed-in Tariff with Contract for Difference (FIT CfD), which will be available in a transition from 2014. There are still some uncertainties about the detailed structure of the FIT CfD, however DECC intends to release two technical papers soon which we expect will offer more transparency. The FIT CfD should offer more certainty over revenue and as it is considered more efficient in terms of cost should help to encourage longevity. Overall it should offer more ‘TLC’ and we see it as being a positive regulatory step for the offshore wind sector.

Additionally, we expect to see more investment in key areas of the supply chain, such as port developments, maintenance vessels and supporting onshore infrastructure and transmission capacity to support such significant offshore growth.
Executive Summary

In November, 2010 we published ‘The UK Renewable Energy Opportunity: Creating Industries & Jobs,’ addressing the country’s renewable power and heat sectors and closely examined the new policy structures in place to support them. This update instead focuses in more detail on the country’s offshore wind resource. We set out to look at the opportunity in the UK then the cost, finance implications and supply chain challenges that may come into play, as well as assessing solutions to these challenges.

Exhibit 1: Key UK Offshore Wind Statistics

| Installed Capacities & Resource Potential | Total UK power capacity installed 2011 | 82 GW |
|                                         | Total potential crown estate offshore wind capacity¹ | 54 GW |
|                                         | Total installed offshore wind capacity (2011) | 1.5 GW |

| 2020 Capacities | 2020 scenario for offshore wind installed capacity at current cost | 13 GW |
| 2020 Capacities | 2020 scenario for offshore wind installed capacity at reduced cost² | 18 GW |

| Costs | Current cost of Round 3 offshore wind (2014) | £2.4-£3.4 million/MW |
| Costs | Estimated cost of Round 3 offshore wind 2015 | £2.3-£3.3 million/MW |
| Costs | Current cost of Round 2 offshore wind (2010) | £2.3 -£3.2 million/MW |
| Costs | Estimated cost of Round 2 offshore wind 2015 | £1.9 -£2.6 million/MW |
| Costs | Current levelized cost of offshore wind in the UK | £149/MWh to £191/MWh |
| Costs | Targeted levelized cost of offshore wind in the UK in 2020 | £100/MWh |

| Investment Requirement | Capital requirement to meet 13GW offshore wind at current cost | £39 billion |
| Investment Requirement | Capital requirement to meet Round 3 offshore wind projects³ | £100 billion |
| Investment Requirement | Capital requirement to meet all leased offshore wind Rounds³ | £150 billion |

| Job Creation | Potential jobs created by offshore wind by 2020⁴ | Up to 70,000 |

Notes: All capital requirements include transmission
¹ The total amount of capacity available under Round 1, 2, 3, extensions and in Scottish Territorial Waters as released by The Crown Estate.
² If costs reduce to £100/MWh then 18 GW can be achieved. Climate Change Committee warns that 13 GW may be more economically sustainable if costs are not reduced.
³ Based on current CAPEX costs of £3m/MW
⁴ Based on various studies
Source: DECC/C7A Analysis, 2011.

The UK possesses some of the richest offshore wind renewable energy resources in the world with near-shore capacity factors between 35-40% and Round 3 capacity factors expected to be over 40%. Harnessing this could provide a clean and reliable source of energy, as well as making a very substantial contribution to the country’s economy with huge opportunities available for British jobs and economic development, including export potential. The UK is already the global leader in the offshore wind sector with over 40% of the world’s generating capacity in UK waters and an installed capacity of 1.5 GW. The sector has a critical role to play in delivering the UK’s renewable energy targets by 2020.
The Government has made clear its commitment to increasing the deployment of renewable energy and in particular offshore wind. In its 2011 UK Renewable Energy Roadmap the central range indicated that up to 18 GW of installed offshore wind capacity could be deployed by 2020 if the levelized cost of energy is reduced to £100/MWh. In total, under leasing rounds conducted to date (Rounds 1, 2, 3, Round 2 extension and Scottish Territorial Waters zones), ~54 GW of installed capacity has been awarded by The Crown Estate for possible development as shown in Exhibit 3.

Exhibit 3: Offshore Wind Leased Capacity in the UK:
Estimates suggest that the capital investment that will be required to install Round 3 wind projects will be ~£100 billion, based on current average costs of ~£3 million/MW, and up to £150 billion for all of the current undeveloped offshore wind sites leased by The Crown Estate.

Costs must be reduced if 18 GW installed capacity is to be realized by 2020. If costs are not reduced, the Committee on Climate Change has cautioned that the UK ambition for offshore wind should be limited to its previous 13 GW ambition, implying £39 billion of investment by 2020.

As an example, we calculate that to achieve 18 GW of installed offshore wind capacity at this same cost (~£39 billion) by 2020 necessitates cost reductions such as to an average of ~£1.9m/MW for Round 2 projects and ~£2.3m/MW for round 3 projects – DECC’s low-end 2015 CAPEX estimates for each Round as shown in Exhibit 4.

Exhibit 4: Low and Median CAPEX for Round 2 and Round 3 Offshore Wind Projects (2010-2030)

Source: DECC: Renewable Obligation Consultation, July, 2011
Note: capital costs exclude ‘other infrastructure’ costs (such as water, roads, waste). Future cost projections assume that steel prices remain constant in real terms and future cost projections apply central learning rates to high, median and low costs rather than the low learning rates to the high costs and the high learning rates to the low costs.
Executive Summary

Current levelized cost for offshore wind in the UK ranges from £149/MWh to £191/MWh as seen in Exhibit 5. DECC has initiated a Task Force to set out an action plan to reduce the levelized costs of offshore wind to £100/MWh by 2020, cost reductions which could lead to the 18 GW capacity scenario.

Exhibit 5: Levelized Cost of Electricity (LCOE) for various renewable technologies

<table>
<thead>
<tr>
<th>£/MWh</th>
<th>2010 financial close</th>
<th>2015 financial close</th>
<th>2020 financial close</th>
<th>2025 financial close</th>
<th>2030 financial close</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshore Wind</td>
<td>Low</td>
<td>149</td>
<td>123</td>
<td>95</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>169</td>
<td>139</td>
<td>107</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>191</td>
<td>158</td>
<td>121</td>
<td>111</td>
</tr>
<tr>
<td>Offshore Wind R3</td>
<td>Low</td>
<td>168</td>
<td>168</td>
<td>127</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>192</td>
<td>192</td>
<td>145</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>225</td>
<td>225</td>
<td>170</td>
<td>151</td>
</tr>
<tr>
<td>Onshore Wind &gt;5MW</td>
<td>Low</td>
<td>75</td>
<td>72</td>
<td>71</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>91</td>
<td>88</td>
<td>86</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>108</td>
<td>105</td>
<td>103</td>
<td>101</td>
</tr>
<tr>
<td>Onshore Wind &lt;5MW</td>
<td>Low</td>
<td>82</td>
<td>80</td>
<td>78</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>104</td>
<td>102</td>
<td>99</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>127</td>
<td>125</td>
<td>122</td>
<td>120</td>
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<tr>
<td>Solar</td>
<td>Low</td>
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<td>165</td>
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<td>120</td>
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<td></td>
<td>Medium</td>
<td>282</td>
<td>228</td>
<td>187</td>
<td>164</td>
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<tr>
<td></td>
<td>High</td>
<td>380</td>
<td>306</td>
<td>250</td>
<td>218</td>
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Note: According to DECC, LCOE costs are a convenient shorthand summary of all project cost information. They are a single figure used to represent the sum of all lifetime generation costs - capital, operating and fuel costs - in relation to the amount of lifetime electricity generation. The low and high figures are based on Arup/Ernst & Young high and low CAPEX, but use DECC’s central assumptions for all other input data.
Executive Summary

A further major issue for delivering the UK’s offshore wind capacity is the need for finance, especially at the pre-construction and construction phases of projects. Historically utilities have financed offshore wind projects through their balance sheets, however in light of the scale of capital required, additional sources of debt and equity will be needed. The Green Investment Bank (GIB) could play a role in providing debt and equity at the construction and operational stages of projects and the European Investment Bank (EIB) could offer debt finance at both stages, however this will only be part of the solution and other sources of finance such as institutional investors will be needed to close the finance gap, see Exhibit 6.

Exhibit 6: Possible Public and Private Finance Sources and Financing Instruments

<table>
<thead>
<tr>
<th>Project</th>
<th>Pre-construction</th>
<th>Construction</th>
<th>Operational (excluding regulatory support)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equity</td>
<td>Debt</td>
<td>Equity</td>
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<tr>
<td>Public Finance Sources</td>
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<td>GIB</td>
<td>GIB</td>
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<td></td>
<td></td>
<td>EIB/International Finance Institutions</td>
<td>International Finance Institutions</td>
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<td>Export Credit Agencies</td>
<td>Sovereign Wealth Funds</td>
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<td>Public Financing Instruments/</td>
<td>N/A</td>
<td>Senior Debt</td>
<td>First Loss Equity</td>
</tr>
<tr>
<td>Vehicles</td>
<td></td>
<td>Subordinated debt/Mezzanine Debt</td>
<td>Equity co-investment (on Pari Passu terms/equal terms)</td>
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<tr>
<td></td>
<td></td>
<td>First Loss Guarantee</td>
<td>Project Bond Initiative¹</td>
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<tr>
<td></td>
<td></td>
<td>Project Bond Guarantee</td>
<td>Export Credit Guarantees</td>
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<td>Private Finance Sources</td>
<td>PE Firms</td>
<td>Commercial Banks</td>
<td>PE Firms</td>
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<td>Project Developers</td>
<td>Utilities</td>
<td>Utility Managers</td>
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<td></td>
<td>Hedge Funds</td>
<td>Insurance Companies</td>
<td>Individuals</td>
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<tr>
<td></td>
<td></td>
<td>High Net Worth Individuals</td>
<td>Pension Funds</td>
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<td></td>
<td></td>
<td>Equipment Vendors</td>
<td>Equipment Vendors</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Construction companies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Insurance Companies</td>
</tr>
<tr>
<td>Private Financing Instruments/</td>
<td>Common Equity</td>
<td>Commercial Loans</td>
<td>Common Equity</td>
</tr>
<tr>
<td>Vehicles</td>
<td></td>
<td>(construction bridge financing or long term debt)</td>
<td>Preferred Equity</td>
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<td>Renewable Debt Funds</td>
<td>Private Equity Funds</td>
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<tr>
<td></td>
<td></td>
<td>Corporate Bonds issued by utilities</td>
<td>Infrastructure Funds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project Bond Initiative¹</td>
<td></td>
</tr>
</tbody>
</table>

¹ EU Project Bond Initiative pilot stage will establish debt capital markets as an additional source of financing for infrastructure projects; and stimulate investment in key strategic EU infrastructure in energy. The aim is to attract institutional investors to the capital market financing of projects with stable and predictable cash flow generation potential by enhancing the credit quality of project bonds issued by private companies.² Pari Passu Equity co-investment is where one series of equity has the same rights and privileges as another series of equity. The GIB could provide part of the capital on equal terms with other sponsors enabling more capital to develop. Where there is a shortage of senior debt finance, the GIB could lend on a pari passu basis with other financial institutions. Source: DBCCA Analysis, 2011
Executive Summary

Regulatory policies are crucial to finance and must show ‘TLC’ – Transparency, Longevity and Certainty. Policy clarity from the Electricity Market Reform is vital to encourage investor lending. Banks and other institutional investors see regulatory risk as important as technology and resource risks. Over complicating reviews and transitional policy arrangements could reduce lender appetite.

The Current Support Mechanism for Offshore Wind

- Standing at the top of the regulatory commitment is the UK’s share of the EU Renewable target for 2020, which in this case is the UK’s 15% renewable energy mandate. Failure to meet this target would result in the European Commission initiating infringement proceedings against the UK, which would be settled in the European Court of Justice and subject to fines. Hence the Government is incentivized to meet it. However, there are no legally binding targets for offshore wind and the costs will have to be acceptable.
- The UK’s market incentive to develop large scale renewable power projects is currently the Renewable Obligation (RO). The RO obligates electricity suppliers to source an increasing proportion of their power from renewable generation, or pay into the buy-out fund instead. It is designed to provide 20 years of support for large-scale renewable electricity projects and will run until 2037.
- There are a number of ways of meeting the obligation: buying ROCs (i.e. RO Certificates), generating ROCs by building and operating renewable plant, or paying a current £38.70/MWh buyout price, which is in effect a floor price and operates much like a tariff in that sense. The buyout price is linked to the retail price index. Revenues generated from the buyout price are split (recycled) pro-rata amongst compliant suppliers. Excess ROCs can be banked for future years and can be converted to carbon credits and sold in the UK Emissions Trading Scheme.
- Currently offshore wind receives 2 ROCs/MWh. The Government’s current consultation document on ROCs in the period 2014-2017 proposes reducing this to 1.9 ROCs/MWh for 2015/16 and 1.8 ROCs/MWh for 2016/17. The Government states that Carbon Price Support will be worth around 0.1 ROC by then. So with a wholesale price of ~£50, this gives ~£130/MW which is generally competitive for offshore wind development currently.

The New Support Mechanism for Offshore Wind

- As part of the Government’s Electricity Market Reform (EMR) process, new offshore wind projects will no longer be eligible for the Renewable Obligation from 2017. Instead they will be supported by a Feed-in Tariff with Contract for Difference (FiT CfD) (Existing projects will continue to receive ROCs for 20 years from date of accreditation).
- The FiT CfD is a long-term financial contract between a low-carbon generator and a central counterparty, under which payments are made to reference the difference between a strike price (tariff) specified in the contract and the value of an exogenous reference price (the wholesale price).
- The FiT CfD was selected over a Premium or Fixed FiT as it was said to offer the best balance of results across 4 key criteria as it was: Potentially more cost-effective; complementary to other elements of the EMR; a more resilient and flexible mechanism which will operate effectively in a wider range of scenarios; and able to provide more certainty that carbon targets will be met than premium FiTs as the impact of uncertain future wholesale price is removed in favour of predicative revenue.
- Offshore wind will be eligible for a FiT CfD for intermittent generation which will be a two-way FiT CfD paid on metered output, except that if the output is constrained by the System Operator for grid balancing reasons the payment would be based on availability. The reference price for the FiT CfD will be calculated according to the day ahead market.
- The RO will transition to the FiT CfD according to the following schedule:
Executive Summary

Exhibit 7: Changes to Offshore Wind Support – RO to the FiT Cfd

| April 2014 | Introduction of FIT Cfd | Generation already accredited at the introduction of the FiT Cfd will remain within the RO and will not have an option to switch |
| April 1, 2014 to March 31, 2017 | Commissioned projects choose between RO or FIT Cfd | Generation accrediting between the introduction of the FiT CFD and 31 March, 2017 will have a one-off choice between the RO and the FIT Cfd. (Projects where at least one turbine is commissioned before 2017 can choose to receive ROCs for the whole period for 20 years from the point of first accreditation) |
| March 31, 2017 | The RO will close to new generation | New generation projects will not be able to accredit under the RO from 31 March, 2017 and after that time, generation will only be eligible for the FiT Cfd (apart from later phases of projects which were begun before the cut-off date) |
| April 1, 2017 to March 31, 2037 | Vintage RO takes over | It is proposed that the vintage RO from April 2017 will be calculated on the current basis of headroom until 31 March, 2027; will be based on Fixed ROC from April 1, 2027 to March 31, 2037; and will grandfather any non-grandfathered technologies at the RO support level applicable on 31 March, 2017. |

Source: DECC, 2011; DBCCA Analysis, 2011

The FiT Cfd Should Provide More TLC

DECC states that the arrangements for transition from the Renewable Obligation to a FiT Cfd are based on DBCCA’s own principles of transparency, longevity and certainty. So, what can a FiT Cfd deliver in terms of TLC?

- **Transparency** – the transition needs to be a fully documented process. The FiT Cfd is complex and although the reforms are intended to create an enhanced investment environment offering greater certainty and higher returns for investors, there is some uncertainty in the immediate-term until the new system of incentives are fully understood. This should be addressed in the soon to be released technical papers.

- **Longevity** – it must be ensured that there is a strong legal framework in place for the new FiT Cfd and that it cannot be altered dramatically at a later stage. It must also be cost effective so that pressure does not come to bear to change it dramatically. The FiT Cfd is considered a cost efficient mechanism. The UK Government has a wide-ranging and long-standing policy of not retrospectively changing contracts, so that existing investors receive what they were promised even if there are any regime changes for new projects.

- **Certainty** – can deliver predictable revenue through the establishment of tariffs. At this stage, no detailed tariffs have been set, but they will be set administratively up to 2020 and then provide more certainty than the RO.

Outstanding Regulatory Issues Relating to TLC

- The Renewable Obligation encouraged purchasing of renewable electricity. However replacing it with the FiT Cfd removes this obligation to source from renewable suppliers. But given the EU target and need to deploy renewable energy, financial incentives are expected to reflect the need to reach that overarching target.

- The RO system is now well understood and is thus working well (albeit with hiatuses every four years due to the need to review banding levels). Complexity associated with the FiT Cfd and the two variants for baseload and intermittent generation need to be explained transparently.
Executive Summary

- A decision is still needed on the institutional framework for delivery of FIT CfD. The delivery organizations could be a new Executive Agency, an existing body or a new private sector body or public corporation.
- There are still elements of the FIT CfD that need to be refined such as the volume of the contract; the likelihood and impact of negative prices in the future; on which index to base the reference price; the contract duration; the enforcement of contract obligations; and the terms for credit and collateral.
- The FIT CfD proposals are subject to the final design of any Capacity Mechanism. The interactions between the FIT CfD and the Capacity Mechanism are potentially complex. The Government is considering including an element of paying for capacity within the FIT CfD. Finalization of the Capacity Mechanism is thus important to the overall timetable.

Two technical papers relating to the EMR and the FIT CfD are expected to be released in the coming two months and should address many of these issues.

Supply Side Issues

Non-financial barriers including infrastructure constraints, planning procedures and delays in grid connectivity for renewable generators are also integral issues to address. In the UK, grid infrastructure and grid connection availability has long been one of the most recognized challenges to renewable energy development. Further pressure on the transmission system is expected with the development of future offshore wind schemes. There is a real need to reinforce existing onshore transmission assets with new lines and cables so that electricity from other areas, especially offshore, can be supplied to demand centers and the UK Renewable Energy Roadmap sets out proposals for dealing with this issue.

Additionally, the supply chain for offshore wind industry in the UK remains immature and short-term investment in the supply chain is needed to realize the long-term benefits of expanded offshore wind. Round 3 and Scottish Territorial Water development zones assume fast development and construction rates and for this to happen, the domestic supply chain must be capable of intense growth, as detailed in the UK Renewable Energy Roadmap. Whether installing or maintaining, offshore wind turbines need a fleet of vessels equipped to carry out many tasks. Bringing more of the supply chain into the UK offers benefits in terms of reduced exposure to currency movements as well as helping to build a green manufacturing economy.
I. UK Offshore Wind – Opportunities

Offshore wind is the most scalable renewable power generating opportunity for the UK. Already the UK leads Europe in terms of total installed offshore wind capacity and there is ~54 GW of capacity available for development by 2020.

1. RESOURCE AND CAPACITY POTENTIAL

Exhibit 8: Offshore wind capacity in Europe; regional capacities in the UK and the offshore resource

The open sea wind speeds around much of the UK's coast are among the highest in Europe

Wind resources over open sea (>10km offshore for 5 standard heights)

<table>
<thead>
<tr>
<th>Height (m)</th>
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<th>50m</th>
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</table>

Offshore Wind is Most Scalable Renewable Technology To Meet UK Renewable Mandates

As part of its commitment to reduce carbon emissions, the UK Government’s 2009 Renewable Energy Strategy sets out a path to increase the UK’s renewable energy supply to 15% of overall energy consumption. This means that the UK will have to attain ~30% of its electricity generation from renewable sources by 2020. Offshore wind is widely expected to generate around 50% of this, reflecting the fact that the country has Europe’s best offshore wind resource.

Huge Resource and Capacity Potential

- Total offshore wind capacity in the UK is now at ~1.5 GW installed. The UK leads the world in generating electricity from offshore wind farms. In the first six months of 2011 the UK installed more offshore wind farms than in any other country worldwide.
- In the Coalition Government’s Renewable Roadmap, 8 technologies were identified that could deliver 90% of the generation necessary to meet the UK’s 15% renewable target by 2020. Offshore wind offers the most significant power generating opportunity.
- The scale of potential for the UK offshore wind energy sector has been described as ‘phenomenal,’ with near shore capacity factors of between 30-35% and Round 3 capacity factors expected to exceed 40%.
- The reason for such high offshore wind potential is the superb geographical situation of the UK. The UK has potentially the largest offshore wind resource in the world, with its relatively shallow waters and a strong wind resource extending far into the North Sea.
- With such a high offshore potential, the UK has a strategic role in taking leadership in the current EU super grid negotiations to ensure that the UK derives maximum value from its design and implementation.

Development to Date

- The 300 MW Thanet wind farm, off the east coast of England, is currently the worlds largest installed offshore wind farm.
- The London Array, currently under construction will be a very significant 1 GW in installed capacity. It will have 341 turbines and occupy an area of 245 square kilometers in the Thames Estuary between Kent and Essex. The project is responsible for employing ~700 people (Eon, London Array). The majority of these jobs (500) are in offshore operations.
- Offshore wind farm developers lease the seabed on which their infrastructure is to be constructed from The Crown Estate. To facilitate this, The Crown Estate has held a number of allocation rounds, allocating defined areas of the seabed to potential wind farm developers. The first of these rounds was launched in 2001 (Round 1) and intended to act as a demonstration round allowing developers to gain an understanding of developing offshore wind farms.
- Round 2 was launched in 2003 for sites at least 8-13 km offshore. The combined capacity of Rounds 1 and 2 is ~8 GW.
- In May, 2010 The Crown Estate announced awards for the Round 1 and Round 2 project extensions. Three Round 1 and Round 2 offshore farm operators were selected to extend five sites, creating an additional ~2 GW of capacity.
- In January, 2010 The Crown Estate announced the development partners for nine Round 3 offshore wind zones which are significantly larger than the areas in rounds 1 and 2. Many Round 3 leases are in deeper water, further offshore and are more technically challenging (DECC, 2011).
- In October, 2011 The Crown Estate leased 5 GW of further capacity in Scottish Territorial Waters bringing the total potential capacity in the region to ~10 GW.
I. UK Offshore Wind – Opportunities

- The combined generation capacity of Round 3 could amount to 32 GW by 2020 in 9 development zones as shown in Exhibit 9.
- Overall, the combined capacity for Rounds 1, 2 (including extensions) and 3 projects along with STW projects have the potential to add up to **54 GW of capacity** as shown in Exhibit 10.

Exhibit 9: Round 3 Offshore Wind Farms

<table>
<thead>
<tr>
<th>Wind Farm Name</th>
<th>Partner Name</th>
<th>Region</th>
<th>MW Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bristol Channel</td>
<td>RWE Npower Renewables</td>
<td>South West</td>
<td>1500</td>
</tr>
<tr>
<td>Dogger Bank</td>
<td>SSE Renewables, RWE Npower, Statoil &amp; Statkraft</td>
<td>North Sea</td>
<td>9000</td>
</tr>
<tr>
<td>Firth of Forth</td>
<td>SSE Renewables &amp; Fluor</td>
<td>Scotland</td>
<td>3500</td>
</tr>
<tr>
<td>Southern Array</td>
<td>Eon Climate and Renewables UK</td>
<td>South</td>
<td>600</td>
</tr>
<tr>
<td>Hornsea</td>
<td>Mainstream Renewable Power &amp; Siemens Projects Ventures</td>
<td>North Sea</td>
<td>4000</td>
</tr>
<tr>
<td>Irish Sea</td>
<td>Centrica Renewable Energy</td>
<td>Irish Sea</td>
<td>4200</td>
</tr>
<tr>
<td>Moray Firth</td>
<td>EDP Renewables &amp; SeaEnergy Renewables</td>
<td>Scotland</td>
<td>1300</td>
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<tr>
<td>Norfolk Bank</td>
<td>Scottish Power Renewables &amp; Vattenfall</td>
<td>Southern North Sea</td>
<td>7200</td>
</tr>
<tr>
<td>West of Isle of Wight</td>
<td>Eceno New Energy</td>
<td>South</td>
<td>900</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>32200</strong></td>
</tr>
</tbody>
</table>

Source: RenewableUK and Scottish Enterprise, 2011.

Exhibit 10: Total Offshore Wind Potential Capacity UK

<table>
<thead>
<tr>
<th>Offshore Round</th>
<th>Potential Capacity (leased from The Crown Estate)</th>
<th>Capacity Installed (April, 2011)</th>
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<tbody>
<tr>
<td>Round 1</td>
<td>1.5 GW</td>
<td>~1 GW</td>
</tr>
<tr>
<td>Round 2</td>
<td>7.2 GW</td>
<td>~500MW</td>
</tr>
<tr>
<td>Round 3</td>
<td>32.2 GW</td>
<td>-</td>
</tr>
<tr>
<td>Scottish Territorial Waters</td>
<td>10.3 GW</td>
<td>-</td>
</tr>
<tr>
<td>Round 1 &amp; 2 Extensions</td>
<td>2.0 GW</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>54 GW</strong></td>
<td>~1.5 GW</td>
</tr>
</tbody>
</table>


- Exclusivity agreements have also been granted by The Crown Estate for up to 10 GW of generation on Scottish Territorial Waters (STW).
- According to the Government’s 2011 Renewable Energy Roadmap there is currently (as of April, 2011) ~2.6 GW of offshore wind farm projects under construction, with a further 1.3 GW awaiting construction but having been granted consent. Projects in the planning system being considered total ~1.9 GW of capacity. A total of ~50 GW of offshore wind sites are currently undeveloped (only in the planning and concept stage), representing a huge resource opportunity but also vast scale-up challenge given that only 1.5 GW of capacity has been installed in the UK overall between 2002-2011.
I. UK Offshore Wind – Opportunities

The development of offshore wind opens up the opportunity to create green jobs, and support regional development in areas where unemployment is high and local economies are in need of rebalancing.

2. EMPLOYMENT OPPORTUNITIES

Exhibit 11: Projected Jobs along the Offshore Wind Supply Chain under a high and low scenario in 2020

A key focus of recent policy around the world has been the development of ‘green’ jobs. Various studies have shown that thousands of jobs can be created by the growth of renewable energy across all sectors in the UK.

Current Offshore Wind-Related Jobs

- A study by RenewableUK and Energy & Utility Skills estimated that employment in the offshore wind energy sector had quadrupled between 2007 and 2010 to stand at ~3,100 full-time equivalent jobs.
- Over this period, annual construction activity in the offshore wind sector has increased from 470 MW a year to 1,470 MW per year leading to a near quadrupling of construction related jobs.

Projected Offshore Wind-Related Jobs and Economic Growth Prospects

- Recent forecasts of job potential in the offshore wind industry at all stages of the development indicate that the sector could directly employ 15,000-40,000 by 2020, as shown in Exhibit 11. If indirect jobs are also included the range could be 19,000 at the lower end and up to 70,000 at the higher end according to a number of estimates.
- Looking out to 2050, the Carbon Trust estimates that offshore wind could generate between 80,000 to 230,000 jobs based on central or high deployment. A substantial number of these jobs will be generated by the re-development of ports, as well as expected wind supply chain exports from the UK.
- There are some reports that estimate the likely ranges of jobs required at each stage of the supply chain for offshore wind. Forecasts are difficult though as they depend on assumptions about manufacturing and exports and imports.
The aforementioned Pricewaterhouse Coopers report (2010) does, however, outline job potential for each part of the offshore wind supply chain showing that there is a need for high level engineering skills and technicians. It is estimated that the majority of offshore wind jobs will be in construction and operation & maintenance.

A different study by Cambridge Econometrics found that design & manufacturing is far more important in terms of job potential than PwC had estimated in 2020, with around 23,000 people employed under a high scenario where up to 30 GW of wind is installed and construction & installation relatively less important. This is likely due to different assumptions on the opportunities for export in design & manufacturing.

Under all these scenarios, however, there is clearly a need to address a current and prospective shortage of skilled workers at all levels of the renewable energy production chain from technicians through to chartered engineers.

In terms of geographical distribution, a number of locations likely to see employment growth associated with offshore wind in the UK were identified in a UKCES 2011 study using quantitative mapping work, based on existing concentrations of activity within the supply chain. These areas include the East coast of Scotland, the North of England and the South of Wales. This suggests that there may be some clustering of activity. These locations align with policy objectives to spatially rebalance the economy as many of the expected concentrations of activity are outside the South East, which has traditionally been an area of higher employment and economic growth.

This represents a significant regional opportunity to rejuvenate parts of the UK historically known for manufacturing and industry. Many of the manufacturing processes (e.g. wind towers and foundations) for the offshore wind industry could draw on existing skills and knowledge bases in the offshore oil and gas sectors, largely concentrated in the North East of the UK. In addition, many disused brown field port sites along the East coast of the UK (including England and Scotland) and also South Wales have the potential to be redeveloped into offshore wind hubs (and other marine energy hubs), creating local employment. In particular, the location of the Round 3 wind farms is expected to drive employment along the East coast of England and Scotland as it is expected that employment associated with the offshore wind energy supply chain will be located near to the wind farm sites.

However, the Crown Estate noted that “a single region cannot deliver the requirements to support the scale of development alone”. In addition, it must also be considered that some of the manufacturing stage of the supply chain will be based elsewhere in Europe for many years. And there is a risk that in the early stages of developing domestic manufacturing capabilities, the skills will be sourced from outside of the UK.
I. UK Offshore Wind – Opportunities

The planned offshore wind scale up and improvement of domestic infrastructure presents opportunities for new industries and rejuvenation of port space in the UK.

3. ECONOMIC BENEFITS AND INVESTMENT OPPORTUNITIES

Necessary Capital Investments

- Ofgem estimates that to meet the Government’s energy policy goals, £200 billion of investment is needed by 2020, in all forms of low carbon energy development.
- Of this £200 billion of energy related investment needed by 2020, around £32 billion needs to go towards energy networks. The new grid will need to be smarter than the existing network to accommodate more low carbon sources of power, which are often intermittent in nature.
- The Crown Estate estimates that constructing all of the current leased, but as yet undeveloped, offshore wind sites in the UK will cost up to £150 billion based on current costs. Round 3 offshore wind projects alone will require ~£100 billion in capital investments, including £60-70 billion for wind turbines; £10-20 billion for power transmission and £10-20 billion for other items including the supply chain.

A Range of Investment Opportunities: Supply Chain and Infrastructure

- In September, 2011 the Energy and Climate Change Committee released a report stating that the UK will struggle to meet 18 GW of offshore wind capacity without due consideration of the supporting infrastructure that is required.
- **New Generating Capacity and Power Networks:** If the UK is to maintain security of supply then new renewable generation and new conventional power plants will require access to the power grid and some parts of the network may need to be strengthened to accommodate renewable generation. Offshore transmission represents a significant component of offshore wind generation, with the estimated capital cost to connect all of the leased area of ~54 GW of offshore wind generation capacity to the National Electricity Transmission System being over £20 billion.
- **Creating a Robust Domestic Offshore Wind Supply Chain:** There is an urgent need to create a domestic supply chain to reap the full benefits of the offshore wind revolution – a point that is emphasized by the Royal Academy of Engineering. As previously noted, based on a cost of £3million/MW, Round 3 offshore wind farms will require as much as £100 billion to construct, including turbines, transmission costs and supply chain costs. Such investment requires additional capital from international sources and institutional investors, and cannot purely be met by the UK’s Big 6 energy suppliers (British Gas, Scottish and Southern Energy, EDF Energy, nPower, E.ON and Scottish Power). Turbine manufacturers, foundations and cabling are just some of the areas where the UK could take the lead in creating a robust domestic industry around offshore wind. The number of international manufacturers, such as Vestas, Siemens, General Electric, and Gamesa interested in the offshore market and the key multi-national players expressing interest in setting up offshore wind manufacturing factories in the UK is a positive market signal for growth in the industry.
- **Technological Innovation:** There is still progress to be made in developing lower cost, more efficient and more robust wind turbines, particularly for offshore wind where capacity factors are much higher and conditions generally more extreme. If the UK is to become a hub of offshore wind, there is ample opportunity for the country to take the lead in technological innovation in this sector. Venture capital and private equity buy-in to this potential will be critical to making the opportunity a reality.
- **Improving Domestic Infrastructure:** Offshore wind components (e.g. towers) will require very specific marine transportation infrastructure, presenting significant investment opportunities (e.g. ships capable of transporting wind towers). In addition, as previously mentioned, for offshore wind power to be transported from the site of generation to
I. UK Offshore Wind – Opportunities

the consumer, substantial investment in power transmission infrastructure will be required by both the public and private sectors. In terms of installation and maintenance infrastructure these will include the following:

1. **Port Super Hubs**
   - The growth of the offshore wind renewable sector in the UK relies upon there being appropriate onshore port and manufacturing facilities. It will be necessary to redevelop ports to act as ‘super hubs’ that can support manufacturing and construction, as well as contain suitable vessels for the offshore wind industry.
   - The UK Government can play a role in providing financial support for the upgrade of ports, making them capable hubs for a UK supply chain. Investment today is critical and given limited funds it makes sense to develop a select number of locations, each serving a wide geographic region.
   - An industry survey of UK port potential in terms of becoming offshore wind ports identified 20 ports that have the necessary land space and marine capabilities. A study conducted by the former Labour Government concluded that 15 ports would be needed by 2020 to meet the demand of Round 1, 2 and 3 UK offshore wind projects.

2. **Offshore Maintenance Hubs**
   - In Scotland in particular, the legacy of the North Sea oilfields presents an opportunity to repurpose infrastructure to support offshore renewable technologies. The UK thus has a natural advantage in an area where home-grown engineering firms already exist.
   - Disused oil platform infrastructure can be used to support wind turbine construction and can serve as maintenance hubs. Transmission lines and pipes could also be repurposed to serve the renewable sector.

3. **A North Sea Transmission Grid – Super-Grid**
   - A North Sea Transmission Grid, including a HVDC Norway-UK interconnector offers a range of benefits to the UK including increased security of supply in the wake of diminishing North Sea oil and gas assets; access to greater renewable resources; and cross-border trade opportunities.

**Domestic Infrastructure Case Study – Port Hubs**

- For the manufacture and construction of offshore wind farms, ports are well placed to provide an industrial hub for wind turbine manufacturers and will be vital in the installation process offshore. Port operators can provide land and facilities for the manufacture and storage of wind turbines. Building components for manufacture and storage close to the developing offshore wind farm can reduce transport costs for developers.
- A large share of offshore projects are set to be located in the North Sea, particularly off Scotland’s coast, so it is here that the need and opportunity benefits are strongest in developing port infrastructure to guarantee the supply chain. Such re-development of port sites to serve the offshore sector thus serves broad economic and social goals, stimulating urban regeneration, education and employment.
- The UK Government and Scottish Government have allocated a total of £130 million for upgrades at port facilities. This level of funding is a strong recognition by the Government of the importance of port redevelopment in scaling up the UK’s offshore power industry.
- Participating in the development of offshore wind farms provides ports with various revenue generating opportunities. Revenue can be generated by providing both onshore services such as land for substations, as well as offshore marine services such as towage and pilotage services from the shore to the wind farm.
- Assembled turbines will require shipping from the land to the sea for installation and specialist vessels would be needed for this. The specialist vessels can berth and make regular use of port terminals. Also port operating companies are essential to service the offshore wind farms.
I. UK Offshore Wind – Opportunities

- Thus the growth in development of wind farms has created opportunities for UK ports and many are looking to take advantage of these benefits. According to DECC estimates, ~1% of the total installed cost of an offshore wind farm is incurred in port related costs. This means that offshore wind farms provide a potential market for UK ports worth over £150 million per year, totaling up to £800 million by 2020. Including operational and maintenance charges could bring this market to £1 billion.
- An industry survey of UK port potential in terms of becoming offshore wind ports found that 20 ports that have the necessary land space and marine capabilities were identified, as seen in Exhibit 12.
- A study by the previous UK Government of ports concluded that 15 ports would be needed by 2020 to meet the demand of Round 1, 2 and 3 UK offshore wind projects, and BVG Associates call for 6 locations by 2014 in order to meet the 2020 targets for generation.

Exhibit 12: Proposed UK Port Upgrades – 20 ports have been identified that meet the criteria to become offshore wind ports in the UK:

![Map of UK ports identified for offshore wind](image)


- However, a number of factors are preventing ports from entering this new market, such as ownership structures and the economics of the market. Port owners view wind industry players as reluctant to commit to contracts or tenancies which would allow specific investment in terms of quayside or land development for the long term.
- UK ports are in private ownership, so operators are motivated by maximizing the yield on their land. The wind industry may have high demands but is always seeking to reduce costs so presents a tough challenge for port owners if they have a choice of different, higher-earning uses for their land.
- To help overcome this situation, the former Labour Government announced a £60 million competition fund in March, 2010 to help UK ports host offshore wind manufacturers, creating a stable framework to attract renewable investment.
I. UK Offshore Wind – Opportunities

- Such competition for land development will add confidence that the appropriate UK port infrastructure can be made available to support production plans.
- A key positive outcome of the coalition Government’s October 2010 Spending Review was that this port fund was maintained as part of a wider £200 million allocated to low carbon technologies, demonstrating that the new Government is acutely aware of the importance of redeveloping port infrastructure.
- Port capacity could also potentially impact the wider energy infrastructure expansion such as carbon capture and storage (CCS), energy storage and nuclear programmes and is also vital in serving the infant wave and tidal renewable sector. Key infrastructure upgrade considerations must therefore be inclusive of all low carbon technologies’ needs and future budget cuts must take into account the wider benefits of port re-development.
II. UK Offshore Wind – Challenges and Solutions

Despite a huge offshore wind resource, deployment of offshore wind to date has lagged the potential. To meet 18 GW of installed offshore wind capacity by 2020, there needs to be a scale up of twelve times the current installed capacity.

Exhibit 13: The UK power generation mix and installed renewable capacity in 2010

Historical Deployment Rates - Vast Scale-up Needed

- To meet the overall 15% renewable energy target, the UK would need to derive 30% of its power generation from renewable sources by 2020.
- To put this in context, the UK derived ~10% of its power from renewable sources early 2011. And in terms of energy use, the UK overall has the third lowest contribution from renewables compared to any other major EU economy, so the growth in capacity needed will come from a very small base.
- Offshore wind is viewed as the most significant scalable renewable power opportunity for the UK. However there needs to be a vast scale-up in capacity investment and annual roll-out, otherwise the UK risks missing its 2020 renewable energy target.
- The UK’s current installed power capacity is ~82 GW, and there is currently ~1.5 GW of offshore wind capacity installed. Offshore wind therefore represents just 2% of the UK’s total installed capacity.
- According to the National Grid the overall UK total installed power capacity is expected to rise to ~114 GW by 2018. On this basis the UK’s 18 GW by 2020 installed offshore wind ambition would represent ~16% of the UK’s installed power capacity at that time, necessitating a twelve-fold scale up on current installed capacity.
II. UK Offshore Wind – Challenges and Solutions

- There is no doubt, however, that the UK is already established as a market leader in offshore wind, and possesses the most advanced pipeline of projects planned for the next decade.
- The Crown Estate has leased development rights for up to 54 GW of generating capacity sites suitable for offshore wind development, which represents ~65% of the UK’s total power generating capacity in 2010 (82 GW).
- Offshore wind is thus widely accepted as the central focus of the UK’s plans to increase the amount of energy it derives from renewable energy by 2020 as it is one of the few scalable renewable options currently available in the country.
Offshore wind in the UK and globally remains a very costly energy technology. Reducing the capital and operational costs of offshore wind will be critical to ensuring adequate investor returns and competitive viability of this industry.

1. **COSTS**

1a. **The Cost Challenge**

The offshore wind industry needs to ensure that it controls costs so that it can generate a return on investment. There is potential for costs to come down in each of the four main elements of wind farm construction as economies of scale are achieved. However as the UK expands its capacity further there are also risks (in particular, higher installation and O&M costs) associated with moving arrays further offshore into deeper water.

**Levelized Cost of Energy (LCOE)**

**Exhibit 14: Levelized Cost of Energy (LCOE) estimates of selected renewable technologies**

<table>
<thead>
<tr>
<th>£/MWh</th>
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<th>2020 financial close</th>
<th>2025 financial close</th>
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<td>123</td>
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</tr>
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<td>High</td>
<td>191</td>
<td>158</td>
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<td></td>
<td>Medium</td>
<td>91</td>
<td>88</td>
<td>86</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>108</td>
<td>105</td>
<td>103</td>
<td>101</td>
</tr>
<tr>
<td>Onshore Wind &lt;5MW</td>
<td>Low</td>
<td>82</td>
<td>80</td>
<td>78</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>104</td>
<td>102</td>
<td>99</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>127</td>
<td>125</td>
<td>122</td>
<td>120</td>
</tr>
<tr>
<td>Solar</td>
<td>Low</td>
<td>202</td>
<td>165</td>
<td>136</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>282</td>
<td>228</td>
<td>187</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>380</td>
<td>306</td>
<td>250</td>
<td>218</td>
</tr>
</tbody>
</table>


Note: DECC notes that LCOE costs are a convenient shorthand summary of all project cost information. They are a single figure used to represent the sum of all lifetime generation costs - capital, operating and fuel costs - in relation to the amount of lifetime electricity generation. The low and high figures are based on Arup/Ernst & Young high and low CAPEX, but use DECC’s central assumptions for all other input data.
II. UK Offshore Wind – Challenges and Solutions

- According to DECC, the Levelized Cost of offshore wind currently ranges from £149/MWh to £191/MWh, as seen in Exhibit 14.
- Onshore wind by comparison currently has LCOE values between £75/MWh to £127/MWh in the UK. This shows that currently – on an LCOE basis - offshore wind is one of the most expensive renewable power generating technologies and demonstrates a clear need for cost reduction in the sector.

Capital Expenditure Associated with Offshore Wind

Exhibit 15: CAPEX associated with offshore wind is spread across 4 main elements:

- Similar to onshore wind, turbine costs are a significant element of capital expenditure for offshore wind. Balance of plant, installation and planning & development make up the remainder of capital costs – as outlined in Exhibit 15.
- Offshore wind farms have significantly higher capital expenditure requirements due to higher technology costs, shipping costs and grid connection costs when compared to onshore wind. They are also perceived to be higher risk projects by investors.
- Current capital expenditure for offshore projects is typically more than double that of onshore developments and operational expenditure is significantly higher.
- In the last five years costs for offshore wind have escalated dramatically, with capital costs now averaging ~£3 million/MW as shown in Exhibit 16.
- There is a lot of uncertainty of costs associated to Round 3 projects but in scenario’s used by DECC costs will decline from between £2.4m/MW and £3.4m/MW currently, to between £1.9m/MW and £2.7m/MW in 2020 as seen in Exhibit 17.
Exhibit 16: Round 2 Offshore Wind CAPEX at financial close dates (real)

<table>
<thead>
<tr>
<th>£/kW</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>3183</td>
<td>2589</td>
<td>2242</td>
<td>2047</td>
<td>1900</td>
</tr>
<tr>
<td>Medium</td>
<td>2722</td>
<td>2214</td>
<td>1917</td>
<td>1750</td>
<td>1625</td>
</tr>
<tr>
<td>Low</td>
<td>2300</td>
<td>1871</td>
<td>1620</td>
<td>1479</td>
<td>1373</td>
</tr>
</tbody>
</table>


Exhibit 17: Round 3 Offshore Wind CAPEX at financial close dates (real)

<table>
<thead>
<tr>
<th>£/kW</th>
<th>2014</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>3431</td>
<td>3279</td>
<td>2685</td>
<td>2373</td>
<td>2166</td>
</tr>
<tr>
<td>Medium</td>
<td>2825</td>
<td>2699</td>
<td>2211</td>
<td>1954</td>
<td>1784</td>
</tr>
<tr>
<td>Low</td>
<td>2400</td>
<td>2293</td>
<td>1878</td>
<td>1660</td>
<td>1515</td>
</tr>
</tbody>
</table>


Note: capital costs exclude ‘other infrastructure’ costs (such as water, roads, waste). Future cost projections assume that steel prices remain constant in real terms and future cost projections apply central learning rates to high, median and low costs rather than the low learning rates to the high costs and the high learning rates to the low costs.

Exhibit 18: Low and Median CAPEX for Round and Round 3 Offshore Wind Projects (2010-2030)


Note: capital costs exclude ‘other infrastructure’ costs (such as water, roads, waste). Future cost projections assume that steel prices remain constant in real terms and future cost projections apply central learning rates to high, median and low costs rather than the low learning rates to the high costs and the high learning rates to the low costs.
II. UK Offshore Wind – Challenges and Solutions

- Assuming a current cost of £3 million/MW would imply that Round 3 wind farms incur construction costs of ~£100 billion by 2020, far exceeding any other round (based on current costs), as shown in Exhibit 19.
- However DECC has initiated a Task Force to reduce costs by 2020. Without cost reduction the Committee on Climate Change warns that the installed capacity of offshore wind in the UK will only reach 13 GW based on current costs, which implies investment of £39 billion.
- As an example, we calculate that costs will need to fall to DECC’s low-end 2015 estimates for Round 2 and Round 3 offshore wind farms (shown in Exhibit 18) (£1.9m/MW and £2.3m/MW respectively) to imply the same investment level of £39 billion.

Exhibit 19: UK undeveloped offshore wind projects and capital requirements

<table>
<thead>
<tr>
<th>Crown Estate Leasing Round</th>
<th>Total Generating Capacity</th>
<th>Projected Cost in £ billion (@ £3m/MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round 1 (not started)</td>
<td>0.55 GW</td>
<td>£1.65 billion</td>
</tr>
<tr>
<td>Round 2 (not started)</td>
<td>4.29 GW</td>
<td>£12.87 billion</td>
</tr>
<tr>
<td>Round 1 &amp; 2 Extensions</td>
<td>2.03 GW</td>
<td>£6.09 billion</td>
</tr>
<tr>
<td>Round 3</td>
<td>32.2 GW</td>
<td>£96.60 billion</td>
</tr>
<tr>
<td>STW</td>
<td>10 GW*</td>
<td>£30.00 billion</td>
</tr>
<tr>
<td>Totals</td>
<td>50 GW</td>
<td>£147.21 billion</td>
</tr>
</tbody>
</table>

Source: The Crown Estate; DBCCA Analysis, 2011

- The expected increased CAPEX out to 2020 (and indeed OPEX out to 2015) of Round 3 projects takes into account technical characteristics of sites further offshore and more challenging development environments.
- Data from UK Round 1 and 2 projects shows that distance from shore is the main driver for cost of electrical infrastructure. On average, electrical infrastructure cost per MW will nearly double for projects located 10 km from shore compared to projects sited 20 km from shore.
- The key drivers of future capital costs are steel prices, exchange rates, labour and vessel costs, according to DECC.
- Industry learning is the primary cause of anticipated declining turbine costs.
- The Crown Estate anticipate that CAPEX are likely to rise to the middle of the decade as tougher offshore sites are developed, then fall as the benefits of new technology outweigh the challenges of later Round 3 sites.
- Compared to the CAPEX of onshore wind, it can be seen in Exhibit 20 that Round 3 offshore wind is highest for each year out to 2030.
II. UK Offshore Wind – Challenges and Solutions

Exhibit 20: Comparing median CAPEX estimates of offshore wind onshore wind at financial close date (real)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshore Wind Round 3</td>
<td>2825</td>
<td>2699</td>
<td>2211</td>
<td>1954</td>
<td>1784</td>
</tr>
<tr>
<td>Offshore Wind Round 2 (&gt;100MW)</td>
<td>2722</td>
<td>2214</td>
<td>1917</td>
<td>1750</td>
<td>1625</td>
</tr>
<tr>
<td>Onshore Wind &gt;5MW</td>
<td>1524</td>
<td>1456</td>
<td>1408</td>
<td>1371</td>
<td>1336</td>
</tr>
<tr>
<td>Onshore Wind &lt;5MW</td>
<td>1548</td>
<td>1479</td>
<td>1430</td>
<td>1393</td>
<td>1357</td>
</tr>
</tbody>
</table>


- There is a significant level of R&D in relation to wind turbine technology and foundation design that may impact the overall costs and economic viability of these projects as well as a maturing supply chain.

Operating Expenditure Associated with Offshore Wind

- Operating costs (OPEX) for offshore wind include operation and maintenance services from wind turbine suppliers, port activities, license fees and other O&M support, labour costs, insurance and grid charges as shown in Exhibit 21.

Exhibit 21: OPEX associated with offshore wind is spread across 5 main elements:

![OPEX associated with offshore wind](image)
II. UK Offshore Wind – Challenges and Solutions

- Current OPEX for Round 3 offshore wind projects fall between £110,076/MW/year and £220,705/MW/year. These are expected to decline to between £86,189/MW/year and £172,810/MW/year by 2020.
- The large ranges are due to site-specific characteristics as well as stakeholder uncertainty over future costs.

Exhibit 22: Round 2 Offshore Wind Fixed OPEX (£m/MW/year) at financial close (real)

<table>
<thead>
<tr>
<th>£/MW/y</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>172,858</td>
<td>140,656</td>
<td>121,859</td>
<td>111,299</td>
<td>103,358</td>
</tr>
<tr>
<td>Median</td>
<td>156,004</td>
<td>126,942</td>
<td>109,977</td>
<td>100,447</td>
<td>93,280</td>
</tr>
<tr>
<td>Low</td>
<td>110,154</td>
<td>89,633</td>
<td>77,655</td>
<td>70,925</td>
<td>65,865</td>
</tr>
</tbody>
</table>


Exhibit 23: Round 3 Offshore Wind Fixed OPEX (£m/MW/year) at financial close (real)

<table>
<thead>
<tr>
<th>£/MW/y</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>220,705</td>
<td>210,918</td>
<td>172,810</td>
<td>152,794</td>
<td>139,553</td>
</tr>
<tr>
<td>Medium</td>
<td>168,641</td>
<td>161,163</td>
<td>132,044</td>
<td>116,750</td>
<td>106,633</td>
</tr>
<tr>
<td>Low</td>
<td>110,076</td>
<td>105,195</td>
<td>86,189</td>
<td>76,205</td>
<td>69,602</td>
</tr>
</tbody>
</table>


Exhibit 24: Median Fixed OPEX Estimates for Offshore Wind Rounds 2 and Round 3

II. UK Offshore Wind – Challenges and Solutions

- OPEX for Round 2 and 3 wind projects is expected to drop quite sharply as seen in Exhibit 24 from the middle of the decade, driven by the benefits of next-generation larger turbines. According to the BEWA, it costs less to maintain fewer, larger turbines than smaller machines with the same combined rating.
- Whilst CAPEX will continue to be an area of focus in the offshore wind sector, increasing availability and reducing recurring O&M costs can also lead to significant reductions in the baseline cost of energy, according to Scottish Enterprise.

1b. Cost Solutions

- The Crown Estate has facilitated offshore wind technology development by granting leases for several demonstration sites across the UK. These sites will play an integral part in addressing technical and cost challenges to facilitate construction further from shore in deeper water.
- Cost reduction in the sector through improved R&D is vital. Industry learning is the key cause of declining turbine costs. The scaling up of offshore wind turbines will provide the greatest contribution to falling turbine prices.
- If the cost of energy from offshore wind can be reduced to compete with alternative low-carbon sources, then the size and robustness of the market opportunity will increase substantially. Future costs of energy from low carbon technologies are uncertain. Forecasts have identified an opportunity for the cost of energy from offshore wind to fall by between 20-40% by 2020 based on industry growth and scale; relief of supply congestion (reducing bottlenecks that have restricted intensity of supply); technology related improvements; and financing risk reductions.
- As previously mentioned, in March, 2011 DECC established a Task Force to set out an action plan to reduce the levelized cost of electricity from offshore wind from ~£147-£191/MWh currently to £100/MWh by 2020.
- The Government is also to provide up to £30 million of direct Government support for offshore wind cost reduction over the next 4 years.
- It is estimated that reducing levelized cost to £100/MWh could enable the 18 GW offshore wind scenario to be achieved. Otherwise, based on the current £3m/MW CAPEX costs, the Committee on Climate Change state that just 13 GW of installed capacity would be deployed by 2020.
- Being able to deploy at scale and at reduced cost would also position the UK to exploit commercial opportunities for greater generation in the North Sea. Exporting power generated in UK waters to Europe would be an option, meaning that European countries fund the deployment of additional capacity in UK waters for their own consumption.
- Technology development and industry learning will have a significant impact in offsetting these costs so that costs will gradually fall, despite projects being located in more challenging locations. OPEX per MW installed will decrease substantially over the lifetime of wind farms installed in the next 10 years due to the use of larger and more reliable turbines. Moving to sites further offshore will give developers access to improved wind conditions. This combined with increase in turbine size will increase the energy yield per MW installed by over a fifth over the period considered to 2022.
- There is still progress to be made in developing lower cost, more efficient and more robust wind turbines, particularly for offshore wind where capacity factors are much higher and conditions generally more extreme.
- If the UK is to become a hub of offshore wind, there are many opportunities for the country to take the lead in technological innovation in this sector. Venture capital and private equity buy-in to this potential will be critical to making this opportunity a reality. With the Government, the public sector and industry working in partnership, test facilities and demonstration sites are being made available to help develop new offshore wind technologies such as the European Offshore Wind Deployment Centre in Aberdeen, Scotland. This centre will allow developers and associated
II. UK Offshore Wind – Challenges and Solutions

supply chain companies to test new designs, prove existing products and receive independent accreditation prior to commercial deployment.

- A 2011 study by Scottish Enterprise estimated that the transfer of skills, discussed later in this section, from the oil and gas sector in high potential areas (such as developments services, support structures, offshore substations, skilled technicians and cable lay) could reduce the cost of energy for offshore wind from current levels by 12.6%.

Direct Government Funding as a Mechanism to Reduce Costs

- Direct Government funding is important as it will reduce technology costs and improve domestic infrastructure.
- In the 2011 Renewable Energy Roadmap, the Government set a target to establish a Task Force to set a path and action plan to reduce costs of offshore wind to £100/MWh by 2020, providing up to £30 million of direct Government support for offshore wind cost reduction over the next 4 years.
- The Government also intends to establish an offshore renewable Technology and Innovation Centre (TIC).
II. UK Offshore Wind – Challenges and Solutions

Unprecedented levels of investment will be needed to make the UK’s offshore wind ambitions a reality, requiring easier access to financing.

2. FINANCE

2a. The Finance Challenge

Utility Balance Sheets: Traditional Financing Source Now Constrained

- Offshore wind farms are capital intensive and require large amounts of long-term reasonably priced debt and equity finance to be able to produce power as competitively as possible and generate sufficient margins to provide equity investors with required returns. The ability to obtain this debt and equity is thus critical to the implementation of the UK’s offshore wind pipeline.
- Ofgem estimates that by 2020, £200 billion of investment is required in UK energy infrastructure overall to meet binding emission and renewable targets.
- The Crown Estate estimates that around £100 billion in capital investments will be made by 2020 in delivering Round 3 offshore wind projects (32 GW) including transmission and supply chain costs.
- A major barrier to meeting the UK’s offshore wind target is the difficulty that developers face is therefore the scale and pace of the investment required.
- Offshore wind farm development consists of the following 3 phases: (i) Development/Pre-Construction; (ii) Construction & Installation; and (iii) Operational.
- Securing finance at the pre-construction and construction phases compared to the operational phase is especially challenging.
- This is because the phases present different levels of risks to investors (Exhibit 25) with additional high levels of construction risk at the earlier stages.

Exhibit 25: Risks associated with offshore wind projects

<table>
<thead>
<tr>
<th>Risk Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Risk</td>
<td>Unpredictable weather conditions; untested construction techniques; and potentially severe consequences of accidents create a high level of construction risk for offshore wind projects. Offshore wind developments in Round 3 will be deeper and further out to sea in more challenging environments.</td>
</tr>
<tr>
<td>Technology Risk</td>
<td>The next generation of turbines will have an increased capacity greater than 5 MW which is untested and will heighten the technology risk.</td>
</tr>
<tr>
<td>Operations &amp; Maintenance Risk</td>
<td>There is uncertainty about the required O&amp;M costs over the lifetime of an offshore wind farm project. This cost is related to technology risk but also depends on the impact of adverse weather conditions and availability of required vessels and equipment. As the technology evolves and farms are built further out at sea, O&amp;M risk will increase.</td>
</tr>
<tr>
<td>Volume Risk</td>
<td>The volume risk relates to the unpredictability of the load factor that a particular wind farm will be able to achieve. The average load factor is dependent on the prevailing conditions applicable to a site, but also on annual variations due to weather conditions.</td>
</tr>
<tr>
<td>Price Volatility Risk</td>
<td>Revenues that an offshore wind farm operator is able to secure on a per MWh basis have 3 components – power prices, renewable obligation certificates and levy exemption certificates. The electricity price in the wholesale spot market is volatile and this volatility may increase over time as a higher portion of intermittent generation could mean low or negative wholesale prices when wind output is high and high prices when there is limited wind generation.</td>
</tr>
</tbody>
</table>

Source: PWC, 2010; DBCCA Analysis, 2011
II. UK Offshore Wind – Challenges and Solutions

- The balance of risk and returns needs to be sufficient to attract investors to the offshore wind sector.
- Offshore wind has long lead times where there is not yet a track record to allow financial markets to be comfortable with the construction risks, and as such these risks are being overpriced.
- Historically, two main approaches to financing offshore wind projects have been taken: balance-sheet funding by utilities via the bond market and through direct commercial bank finance known as project finance. Early Round 1 and 2 projects have typically been in the low hundreds of millions in terms of cost.
- The next generation of Round 3 offshore projects, however, will require capital expenditures of the order of £2.4million/MW to £3.4million/MW.
- The higher costs are compounded by growing constraints on the financial capacity of utility balance sheets, competing pressures for capital between various regions and energy sectors they operate in, as well as overarching needs to maintain credit ratings and fulfill shareholder dividend expectations.
- Utilities typically invest an aggregate of £8.6 billion per year in energy infrastructure (in 2009, PWC, 2010), totaling ~£60-80 billion by 2020. On this basis the UK energy investment requirement to 2020 far exceeds the combined funding capability of the Big Six utility firms (British Gas, nPower, Scottish & Southern Energy, EDF, E.ON and Scottish Power). The equity funding into the UK offshore sector from existing participants (i.e. utilities) is therefore finite.

Role of Banks and Private Investors

- In addition to the Big Six funding capacity constraints, the Euro-zone banking crisis has resulted in banks’ having the inclination to slim their loan books as well as having limited capital raising opportunities.
- In addition to this, there are new requirements to increase capital ratios. In particular, higher banking capital requirements imposed by the Basel III banking regulations are being phased in through 2019. Basel III requires that banks hold more capital against long term loans, as compared to short term loans, at a time when accessing new capital is challenging. This may encourage banks to switch towards shorter-term lending perhaps at the pre-construction and construction phases of offshore wind rather than the long-term operational phase, which could limit the availability of new, long-term loans for offshore wind in the market. The exact impact of the Basel III standards on commercial bank finance cannot yet be concluded.

Pre-Construction and Construction Risks and Lack of Finance

- A key issue for offshore wind previously has been that the support mechanisms in place have not addressed the specific challenges pre-construction and construction finance.
- Project finance to support the pre-construction phase (development prior to construction) of offshore wind has been unavailable to date, making finance at this phase more difficult.
- For the construction phase, the associated risks can be deemed too high for some investors to take.
- The development risk of providing project finance to offshore wind farms pre-construction may be too high for banks to accept. Project sponsors would need a guarantee to cover development risks prior to banks considering lending pre-construction. However the sponsors are not keen to provide EPC wrap which makes project finance by banks difficult.
- Private investors such as private equity houses and hedge funds would be willing to accept the [pre]-construction risk provided that the returns were commensurate with it. But at the moment there is a mis-match with risk being high and returns only in line with utility-type returns.
- The result has been that developers must finance offshore wind farms from balance sheets or wait to roll over (recycle) financing once projects are operational, however there is a time lag associated with the latter option.
II. UK Offshore Wind – Challenges and Solutions

- In the absence of available balance sheet funding, the challenge therefore for banks and other financial investors is to take construction risk in the absence of an engineering procurement contract (EPC) wrap from the sponsors.
- In addition a lack of operating history in the form of operational performance benchmarking makes it difficult for institutional investors to evaluate the risk.
- The current supporting mechanisms of Renewable Obligation Certificates (ROCs) and the new FiT CfD are unlikely to address the specific challenges of offshore wind pre-construction financing.

2b. Finance Solutions

Sources of finance for pre-construction, construction and operational phases of offshore wind projects can come from the public and private sectors as shown in Exhibit 26. The Green Investment Bank (GIB) could provide debt and equity at the construction and operational stages of projects and The European Investment Bank (EIB) could provide debt finance at both stages, but public sources of finance will not support the pre-construction phase. Additionally, given the scale of the renewable financing needed though and the competing projects requiring finance, public sources are only a part of the solution.
## II. UK Offshore Wind – Challenges and Solutions

### Exhibit 26: Possible sources of finance for offshore wind projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Pre-construction Equity</th>
<th>Construction Debt</th>
<th>Construction Equity</th>
<th>Operational (excluding regulatory support) Debt</th>
<th>Operational (excluding regulatory support) Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public Finance Sources</strong></td>
<td>N/A</td>
<td>GIB</td>
<td>International Finance Institutions</td>
<td>GIB</td>
<td>International Finance Institutions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EIB/International Finance Institutions</td>
<td>Export Credit Agencies</td>
<td>EIB</td>
<td>Export Credit Agencies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Export Credit Agencies</td>
<td>Sovereign Wealth Funds</td>
<td>Marguerite Fund</td>
<td>Sovereign Wealth Funds</td>
</tr>
<tr>
<td><strong>Public Financing Instruments/Vehicles</strong></td>
<td>N/A</td>
<td>Senior Debt</td>
<td>Subordinated debt/Mezzanine Debt</td>
<td>First Loss Guarantee</td>
<td>First Loss Guarantee (on Pari Passu terms/equal terms)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project Bond Initiative</td>
<td>Export Credit Guarantees</td>
<td>Project Bond Initiative</td>
<td>Export Credit Guarantees</td>
</tr>
<tr>
<td><strong>Private Finance Sources</strong></td>
<td>PE Firms</td>
<td>Commercial Banks</td>
<td>Utilities</td>
<td>Insurers</td>
<td>High Net Worth Individuals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project Developers</td>
<td>Hedge Funds</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commercial Banks</td>
<td>Utilities</td>
<td>Insurers</td>
<td>High Net Worth Individuals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment Vendors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Private Financing Instruments/Vehicles</strong></td>
<td>Common Equity</td>
<td>Commercial Loans (construction bridge financing or long term debt)</td>
<td>Renewable Debt Funds</td>
<td>Corporate Bonds issued by utilities</td>
<td>Project Bond Initiative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Renewable Debt Funds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Infrastructure Funds</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. EU Project Bond Initiative pilot stage will establish debt capital markets as an additional source of financing for infrastructure projects; and stimulate investment in key strategic EU infrastructure in energy. The aim is to attract institutional investors to the capital market financing of projects with stable and predictable cash flow generation potential by enhancing the credit quality of project bonds issued by private companies. Pari Passu Equity co-investment is where one series of equity has the same rights and privileges as another series of equity. The GIB could provide part of the capital on equal terms with other sponsors enabling more capital to develop. Where there is a shortage of senior debt finance, the GIB could lend on a pari passu basis with other financial institutions.

*Source: DBCCA Analysis, 2011*
Insufficient capacity in debt capital markets, perceived risk around policy support frameworks, risk around new technologies being rolled out and difficulties with financing large numbers of smaller projects have made low carbon infrastructure financing unachievable without scaled up Government intervention.

Sufficient levels of finance at the construction phase of offshore wind projects in particular can be hard to come by owing to the associated construction and technology risks.

For these reasons, the Government fully endorses the development of a Green Investment Bank (GIB) to facilitate private finance for a low carbon transition, noting that without unprecedented levels of investment in new green infrastructure, decarbonisation of the UK energy supply will be stalled.

The October, 2010 Spending Review confirmed its establishment of the GIB and in March, 2011 the Chancellor set out in his budget speech that the initial capitalization of the GIB will be £3 billion over the period to 2015.

The GIB will be implemented in 3 phases (Exhibit 27):

- **Phase 1: Incubation**: April 2012 to achievement of state aid approval (the bank will need to be approved by the European Commission before it can be established in full which is why there will be a phased approach). The Government will make direct financial investments prior to the creation of the GIB to accelerate investment in the green economy. This is being done as it is important to attract early action in
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infrastructure and green investment. The Government has allocated £775 million to a small team to make direct, state aid compliant investments in green projects from April, 2012. The Government will make these investments via the Department of Business, Innovation and Skills. Investment decisions will be overseen by an investment committee.

- **Phase 2**: Establishment: The new bank will have to comply with State Aid rules so all proposals will need to be approved by the European Commission before establishment of the GIB. Following the state aid approval, the GIB will be created as a stand-alone bank.
- **Phase 3**: Full borrowing GIB: The Government will enable the GIB to have borrowing powers from 2015-2016 and once the target for overall Government debt to be falling as a percentage of GDP has been met.

**How the GIB Could Finance Offshore Wind**

GIB project analysis found that offshore wind was the most relevant sector for the GIB to assist in terms of the size of investment needed, the timing of required investments and the relevance of financial solutions the GIB could deploy. As yet there has been no official final description of what the GIB might do. However, there have been a number of discussion papers that we can draw upon:

- The GIB could play a key role in finding additional sources of debt and equity finance beyond utility balance sheets at both the construction and operational phase offshore wind projects.
- Possible debt products the GIB could use that might assist offshore wind include:
  - Risk mitigation through first loss debt in the construction phase of projects, to help mobilize additional investment into offshore wind. The GIB could offer a subordinated facility to replace the contingent financing that senior creditors currently provide in some projects to finance construction cost overruns. This could provide two benefits: the contingent commitment previously provided by senior lenders could be freed to be lent into other projects; and the subordination of this facility would improve the risk profile for the senior creditors, potentially bringing new lenders into sectors where they are not currently participants. Construction contingent subordinated debt is likely to be suitable for the offshore wind sector in which large amounts of capital are needed during construction phases.
  - It is possible to provide sub-ordinated debt during operational phase: providing sub-ordinated debt during the operational phase would improve a project’s risk profile for institutional investors. It could enable refinancing of sponsors’ investments with long-term capital market financing. Institutional investors could participate in the operational phase, enabling capital to be recycled into the construction phase of additional projects.
  - Capital provision through straight senior debt on market terms to provide additional capital.
- Possible equity products that the GIB could use that might assist offshore wind include:
  - Capital provision through straight equity on market terms to provide additional capital.
  - The GIB could invest on a pari passu (equal) basis with other financial institutions.
  - First loss equity capital

It is expected that over the coming 6-12 months there will be more details on the GIB and products that might be available.
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Other Offshore Wind Finance Solutions

As previously discussed, access to finance at the pre-construction and construction phases of offshore wind farms is where the predominant bottleneck is. Additionally, regulatory constraints on commercial banks as well as the lack of EPC guarantees and operating history data for financial investors mean that other sources of equity and debt finance, especially for the operational stages of offshore wind projects, are also needed.

Below we explore alternative sources of debt and equity finance at this phase:

Role of the European Investment Bank & the Project Bond Initiative

- The European Investment Bank (EIB) can provide debt finance at the construction and operational phases of offshore wind projects.
- It can provide long-term debt financing for projects that further EU economic policies. In 2010 it loaned a record €19 billion to climate-related projects.
- The EIB is to provide £52 million of funding for the transmission link to the Walney 1 offshore wind farm in the UK.
- The Bank is expected to provide £300 million of finance for 6 of the 9 links to offshore wind farms from the first transitional tender round.
- The EIB also has several separate funding facilities on a corporate basis to utility-led projects. It has provided loan to DONG Energy for the London Array project.
- However in November, 2011 the EIB announced that it may raise the price of loans to renewable energy projects to shore up capital as demands for funds rise. Given that the European debt crisis and banking sector problems have constrained private sector lending, state-backed lenders have increased their funding for renewable energy. However this higher demand may not necessarily be in line with the EIB’s lending capacity. Despite this, the EIB’s commitment to funding clean energy projects is unchanged but this announcement shows that it is by no means a guaranteed or infinite finance solution for offshore wind projects.
- In February, 2011 the European Commission launched a consultation on the ‘Europe 2020 Project Bond Initiative’ developed jointly with the EIB.
- The objective of the Initiative is to help promoters of infrastructure projects that attract additional private sources of finance from investors such as insurance companies and pension funds. This would be achieved through an instrument to improve the rating of the senior debt of project companies, thereby ensuring that this can be placed as bonds with institutional investors.
- The key role of the EIB and European Commission would be in taking on part of the project risk, thus increasing the credit rating of the whole project.
- The European Commission is now proposing to launch a pilot phase of the Europe 2020 Project Bond Initiative. The pilot stage will establish debt capital markets as an additional source of financing for infrastructure projects; and stimulate investment in key strategic EU infrastructure in energy. The aim is to attract institutional investors to the capital market financing of projects with stable and predictable cash flow generation potential by enhancing the credit quality of project bonds issued by private companies. The intention is to support capital market financing of projects as a form of finance to complement loans.
- The European Wind Energy Association calls for the offshore wind sector to be included under the 2020 Project Bond Initiative. Preferably, the initiative will focus on the parts that are most difficult to get bank financing – i.e. for the construction phase and a couple of years into operation. This will also secure faster re-circulation of funds.
- The EU’s Project Bond Initiative may also be a source of operational debt finance.
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Role of Commercial Banks

- Although the exact impact of the upcoming Basel III regulations on commercial bank long term financing capabilities cannot be concluded yet, currently banks do provide project financing for offshore wind projects.
- In the future, this could shift to even shorter tenors or ‘bridge-to-bond’ structures, where the construction financing is provided by banks and once the assets are operational the loans are refinanced through the capital markets (project bonds).

Role of Institutional Investors/Pension Funds and Insurance Companies

- Given that the fundamental drivers of the UK offshore market provide senior debt providers with significant opportunities ahead of 2020 and beyond, it can be assumed that there will be growing interest by various lenders over the coming years.
- Pension funds and insurance companies in general can be the appropriate long-term lenders of debt that finances the operational phase of offshore wind.
- Infrastructure funds are showing greater interest and may grow into an important part of the short to medium term equity finance solution.
- Pension funds are also an increasingly important equity financing stream for green projects. In Denmark in early 2011 two Danish pension funds (PKA and Pension Danmark) invested over $1 billion in the pre-construction phase of an offshore wind farm, acquiring a 50% stake. However, the pension funds were protected against construction risk by securing a commitment from the developer that the wind farm would be delivered at a fixed price and by a certain date. However, re-financing offshore balance sheets through bond issues will prove a challenge as pension fund and bond market investors are generally still a few years away from embracing the full potential of cleantech investments.

Role of Project Developers

- Although utilities and project developers would be unable to finance the largest Round 3 offshore wind farms from their balance sheets alone, they still have a major role to play in the equity financing of smaller Round 2 offshore wind farms at the pre-construction and construction phases in the UK via common equity finance.
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Transparent, long-term and certain (TLC) Government policy support for offshore wind is the key focus for investors.

3. ADDRESSING REGULATORY UNCERTAINTY

3a. Regulatory Challenge

Exhibit 28: DBCCA’s concept of ‘TLC’: Investors essentially look for 3 key drivers in policy


- Before private investors will commit large sums of capital to the renewable energy sector in the UK, and anywhere in the world, there must be transparent, long-term and certain regulations governing carbon emissions, renewable energy and energy efficiency. Investors, in short, need TLC.
- Investors will look for Transparency, Longevity and Certainty (TLC) in assessing the potential success of new UK renewable and low carbon policies.

3b. Regulatory Solutions

The Current Support Mechanism for Offshore Wind

- Standing at the top of the regulatory commitment in the UK’s share of the EU Renewable target for 2020, which in this case is the UK’s 15% renewable energy mandate. Failure to meet this target would result in the European Commission initiating infringement proceedings against the UK, which would be settled in the European Court of Justice and subject to fines. Hence the Government is incentivized to meet it. However, there are no legally binding targets for offshore wind and the costs will have to be acceptable.
- The UK’s market incentive to develop large scale renewable power projects is currently the Renewable Obligation (RO). The RO obligates electricity suppliers to source an increasing proportion of their power from renewable generation, or pay into the buy-out fund instead.
- The RO had an original end date of 2027. However in light of the 2020 targets and the need to encourage investment in renewable energy up to 2020, the operational timeline of the RO has been extended to 2037.
- Accredited renewable generators are issued with Renewable Obligation Certificates for each MWh of eligible energy generated, multiplied by a factor that is dependent on the type of generation technology.
There are a number of ways of meeting the obligation: buying ROCs, generating ROCs by building and operating renewable plant, or paying a current £38.70/MWh buyout price, which is in effect a floor price and operates much like a tariff in that sense. The buyout price is linked to the retail price index. Revenues generated from the buyout price are split (recycled) pro-rata amongst compliant suppliers. Excess ROCs can be banked for future years and can be converted to carbon credits and sold in the UK Emissions Trading Scheme.

Currently offshore wind receives 2 ROCs/MWh. So with a wholesale price of ~£50, this gives ~£130/MW which is generally competitive for offshore wind development currently.

**RO Banding Reviews**

- The most significant change to the RO was in 2009 with the introduction of banding, where different technologies receive varying levels of support – largely based on technology cost.
- For offshore wind this meant an increase in the level of support to 2 ROCs/MWh instead of 1 ROC. Projects that receive full accreditation between 1 April, 2010 and 31 March, 2014 will receive the 2 ROCs/MWh.
- In December, 2010 the Energy Minister announced that the timetable for the 2013 RO Banding Review would be sped up. The review was moved forward to give investors greater certainty around support levels. Under the previously announced timetable, investors would not have known for sure what support would be on offer until autumn 2012.

**Outcome of the RO Banding Review 2011**

- Currently offshore wind needs 2 ROCs/MWh to deploy. An industry-led task force was announced in October, 2011 to set a path and action plan to reduce costs of offshore wind to £100/MWh by 2020. In doing so, this should enable support levels to be reduced without impacting deployment levels.
- In the October, 2011 Banding Consultation DECC proposed that:
  - For new offshore wind projects accredited in 2014/15 the support will stay at 2 ROCs/MWh
  - For new offshore wind projects accredited in 2015/16 the support will be reduced to 1.9 ROCs/MWh
  - For new offshore wind projects accredited in 2016/17 the support will be reduced to 1.8 ROCs/MWh
- This is a slower sliding scale of support than the 1.5 ROCs/MWh from 2015 that had been originally planned – which is good news for the sector.

**The New Support Mechanism for Offshore Wind**

- As part of the Government’s Electricity Market Reform (EMR) process, new offshore wind projects will no longer be eligible for the Renewable Obligation from 2017. Instead they will be supported by a Feed-in Tariff with Contract for Difference (FiT CfD), available in transition from 2014. Existing projects will continue to receive ROCs for 20 years from date of accreditation.
- The consensus is that the current market arrangements will not deliver the scale of long-term investment needed, at the required pace, to meet the challenges. The rationale for the EMR was that in order to meet the challenges of the coming decades the majority of new generation will have to be low carbon. Low carbon generation typically has high construction (capital) costs and low operating costs and resultantly low-carbon plants are wholesale price takers. It is difficult to make a case for them in a market where wholesale electricity prices are set by the short-run marginal costs of unabated coal and gas plants.
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- The FiT CfD is a long-term financial contract between a low-carbon generator and a central counterparty, under which payments are made by reference to the difference between a **strike price (tariff)** specified in the contract and the value of an exogenous **reference price (the wholesale price)**.
- The FiT CfD was selected over a Premium or Fixed FIT as it was said to offer the best balance of results across 4 key criteria as it was: Potentially **more cost-effective**; complementary to other elements of the EMR; a more resilient and flexible mechanism which will operate effectively in a wider range of scenarios; and able to provide more certainty that carbon targets will be met than premium FiTs as the impact of uncertain future wholesale price is removed in favour of predicable revenue.
- A classic two-sided CfD obliges the generator to deliver a certain amount (MW) of power by generating or buying it in the market, for a strike price/tariff. This works well for plants with high capacity factors such as nuclear power, but would be difficult for a wind farm with lower capacity, as for ~75% of the time it would be buying power to sell at the strike/tariff price. If the strike/tariff price were normally above the average wholesale price, this would not be a problem, and might act as an appealing hedge to the generation company having rights over a wind farm – but would constitute a subsidy to fossil generation.
- To remedy this, there will be a separate type of FiT CfD for intermittent generation which will be a two-way Fit CfD paid on metered output, except that if the output is constrained by the System Operator for grid balancing reasons the payment would be based on availability. The reference price for the FiT CfD will be calculated according to the day ahead market.
- The RO will transition to the FiT CfD according to the following schedule in Exhibit 29.

**Exhibit 29: Changes to Offshore Wind Support – RO to the FiT CfD**

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2014</td>
<td><strong>Introduction of FiT CfD</strong></td>
<td>Generation already accredited at the introduction of the FiT CfD will remain within the RO and will not have an option to switch</td>
</tr>
<tr>
<td>April 1, 2014 to March 31, 2017</td>
<td><strong>Commissioned projects choose between RO or FiT CfD</strong></td>
<td>Generation accrediting between the introduction of the FiT CfD and 31 March, 2017 will have a one-off choice between the RO and the FiT CfD. (Projects where at least one turbine is commissioned before 2017 can choose to receive ROCs for the whole period for 20 years from the point of first accreditation)</td>
</tr>
<tr>
<td>March 31, 2017</td>
<td><strong>The RO will close to new generation</strong></td>
<td>New generation projects will not be able to accredit under the RO from 31 March, 2017 and after that time, generation will only be eligible for the FiT CfD (apart from later phases of projects which were begun before the cut-off date)</td>
</tr>
<tr>
<td>April 1, 2017 to March 31, 2037</td>
<td><strong>Vintage RO takes over</strong></td>
<td>It is proposed that the vintage RO from April 2017 will be calculated on the current basis of headroom until 31 March, 2027; will be based on Fixed ROC from April 1, 2027 to March 31, 2037; and will grandfather any non-grandfathered technologies at the RO support level applicable on 31 March, 2017.</td>
</tr>
</tbody>
</table>

*Source: DECC, 2011; DBCCA Analysis, 2011*

Will the FiT CfD Provide TLC?

- DECC states that the arrangements for transition from the Renewable Obligation to a FiT CfD are based on DBCCA’s own principles of transparency, longevity and certainty. So, what can a FiT CfD deliver in terms of TLC?
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- **Transparency** – the transition needs to be a fully documented process. The FiT CfD is complex and although the reforms are intended to create an enhanced investment environment offering greater certainty and higher returns for investors, there is some uncertainty in the immediate-term until the new system of incentives are fully understood. This should be addressed in the soon to be released technical papers.

- **Longevity** – it must be ensured that there is a strong legal framework in place for the new FiT CfD and that it cannot be altered dramatically at a later stage. It must also be cost effective so that pressure does not come to bear to change it dramatically. The final appraisal conducted by the Government showed that the EMR packages under a FiT CfD offer the greatest benefits to society compared to continuing with the current RO policy, thus the FiT CfD is considered a cost efficient mechanism. The UK has a wide-ranging and long-standing policy of not retrospectively changing contracts so that existing investors receive what they were promised even if regime changes occur for new projects.

- **Certainty** – can deliver predictable revenue through the establishment of tariffs. At this stage, no detailed tariffs have been set, but they will be set administratively up to 2020 and then provide more certainty than the RO.

### The Transition from RO to FiT with CfD for Offshore Wind

- The phase-out of the Renewable Obligation will happen in stages, as previously shown in Exhibit 24 above.
- Within the vintage scheme the Government will continue to set the obligation annually using the current ‘headroom’ mechanism until 2027. From 2027 a ROC will be set at a fixed price at its long-term value and the Government will buy the ROCs directly from generators. This is intended to reduce volatility in the final years of the RO.
- According to the Government’s EMR White Paper, investors with projects in the pipeline say that this gives them certainty over the ROC income and allows them to access the full value of the ROC rather than having to take a discount through a PPA with a supplier.
- The Government intends to work closely with relevant parties to explore the means by which they can provide early certainty to low-carbon projects that are intended to benefit from the Fit CfD scheme, but that require a final investment decision before the scheme is implemented.
- Additionally, the Scottish Government is committed to working in partnership to deliver a coherent and seamless package of reforms across the UK. The UK Government will continue to involve the Scottish Government in further working on EMR in the design of the FiT CfD and managing a smooth transition from the RO to the FiT CfD.

### Outstanding Regulatory Issues Relating to TLC

- The Renewable Obligation encouraged purchasing of renewable electricity. However replacing it with the FiT CfD removes this obligation to source from renewable suppliers. But given the EU target and need to deploy renewable energy, financial incentives are expected to reflect the need to reach that overarching target.
- The RO system is now well understood and is thus working well. Complexity associated with the FiT CfD and the two variants for baseload and intermittent generation need to be explained transparently.
- A decision is still needed on the institutional framework for delivery of FiT CfD. The delivery organizations could be a new Executive Agency, an existing body or a new private sector body or public corporation.
- There are still elements of the FiT CfD that need to be refined such as the volume of the contract; the likelihood and impact of negative prices in the future; on which index to base the reference price; the contract duration; the enforcement of contract obligations; and the terms for credit and collateral.
- The FiT CfD proposals are subject to the final design of any Capacity Mechanism. The interactions between the FiT CfD and the Capacity Mechanism are potentially complex. The Government is considering including an element of
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paying for capacity within the FiT CfD. Finalization of the Capacity Mechanism is thus important to the overall timetable.

Two technical papers relating to the EMR and the FiT CfD are expected to be released in the coming two months and should address many of these issues.
Aside from cost reductions and finance streams, the timely and efficient installation of infrastructure to transport new renewable power capacity and the development of a domestic supply chain is vital if the UK is to meet its 2020 renewable target.

4. TRANSMISSION & SUPPLY CHAIN

4a. Transmission & Supply Chain Challenges

Exhibit 30: Projected UK Energy Flows in 2020

Source: National Grid Seven Year Statement, 2010 ©
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Transmission Upgrades and Grid Connectivity

- Offshore transmission transports electricity from offshore generation sites back to the UK’s onshore grid. The timely and efficient installation of this infrastructure is a key enabler of deploying offshore wind to help meet the UK’s 2020 renewable energy target. Offshore transmission represents a significant component of the total cost of offshore wind generation.
- The Crown Estate has initiated a dedicated Transmission Programme to play a more effective and proactive role in the delivery of the necessary offshore infrastructure.
- Immediate challenges to address include sustainable use of seabed and foreshore for cable corridors to cope with more cable lying activities; regulatory improvement to enable offshore energy projects to secure connections in a timely, reliable way; development of a transmission network that will contribute to the aim of reducing cost and risks of delivering offshore renewable and delivery of offshore transmission to avoid unnecessary consenting delays; mitigation of potential bottlenecks in supply of offshore export power caballing.
- The UK’s grid and transmission system is heavily reinforced in former coal-mining regions, but has limited capacity in many areas that are best suited for renewable energy generation.
- The predominant power flow on the GB transmission system is from the north where most energy is produced, towards the south where the majority is consumed, see Exhibit 30. There is a net export of power from Scotland to the south and the circuits between these regions are already operating at their maximum capacity.

Offshore Wind Grid Connection

- To deliver the increase in offshore generation expected by 2020, the UK will need significant and timely investment in the grid. The Crown Estate estimates that ~£10 billion of transmission investment will be needed to connect all Round 3 projects to shore.
- According to a 2009 Electricity Networks Strategy Group study, offshore wind generation in England and Wales raises a number of connection issues onshore; particularly in Wales and along the English East Coast between the Humber and East Anglia. The increased power transfers across the North to the Midland’s boundary and increased generation off the East Coast and Thames Estuary results in severe overloading of the northern transmission circuits around London.
- Developing the UK’s offshore renewable energy resource will require large sub-sea electrical cables connecting regions of high resource concentration, and between the UK and mainland Europe.
- The strong likelihood of significant offshore renewable generation development in Scotland means that an extensive upgrade of the onshore transmission system (including offshore cable links) is likely to be required to facilitate transmission of power south to England.
- When the transmission regime is introduced, the grid connections will be controlled by new Offshore Transmission Operators with specific responsibility for constructing and maintaining individual offshore networks to encourage competition and reduce prices. The risk is that this will result in a number of ‘point-to-point’ transmission systems, rather than a network of connected installations or a national offshore grid.
- This needs to be carefully managed to ensure that the new individual offshore grids are constructed in such a way that they are flexible enough to connect to a possible North Sea Supergrid with the rest of Europe, and to allow connection for other marine renewable technologies such as wave and tidal. Renewable UK highlights that if the transmission regime is not right then the scale and timing of delivering grid connections could reduce the efficiency of the process.
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The Supply Chain

<table>
<thead>
<tr>
<th>Research, Design &amp; Development</th>
<th>Pre-engineering</th>
<th>Manufacturing</th>
<th>Construction</th>
<th>Operations &amp; Maintenance</th>
<th>Decommissioning</th>
</tr>
</thead>
</table>

Exhibit 31: Turbine and Component Manufacturing in the UK

- Siemens, General Electric & Gamesa are planning to build new wind power manufacturing plants on the East and North East coast.
- Gamesa is to set up an offshore wind technology centre in Glasgow.
- MabeyBridge wind turbine facility opened in May, 2011.
- Welcon Towers (part of Skylon) is to set up a research and services base for offshore wind in Argyll.
- Vestas may build a wind turbine factory in Kent in the next 12 months.
- Regions where the unemployment rate is above the overall UK average of 7.8% (March-May 2010).

The supply chain can be described as the engineering and manufacturing infrastructure and resources that support the construction of offshore wind farms. It covers turbine manufacture, balance of plant manufacture and engineering resource.

Only if a strong UK-based supply chain is established, can the UK unlock the renewable energy industry’s potential for job creation and foster the business environment to attract, build and sustain enterprises across it.

The equipment and construction supply chains for offshore wind in the UK are still at the early stages of development and there is still a lack of capacity and competition overall, especially in the production of key components, such as export cables, electrical equipment and the vessels required to install them, according to DECC’s 2011 Renewable Roadmap.
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- A key supply chain issues affecting the offshore wind supply chain is turbine manufacturing.
- The European offshore wind turbine market has been dominated by Vestas Wind Systems and Siemens Wind Power, who hold 90% of installed capacity, and are headquartered in Denmark and Germany respectively.
- By comparison, the UK turbine component supply chain is limited due to the fact that supply chains grew up alongside their expanding customers in Denmark, Germany and Spain, so there are well-established suppliers in these places.
- The UK will need to overcome supply chain barriers to lower costs of offshore wind and achieve deployment at the scale needed by 2020 and beyond.

There have, however, been some positive developments in creating a domestic supply chain over the past 2 years as seen in Exhibit 31 above:

- In light of the UK’s huge offshore resource, and the commitments by the UK coalition Government and the Scottish Government to fund port upgrades, there have been a wave of recent positive announcements regarding domestic component manufacturing.
- In January, 2011 following the announcement of Round 3 offshore wind farm development German energy technology firm Siemens announced that they are to go ahead with building a wind turbine manufacturing plant in Hull, expected to be operational by 2014 and creating 700 jobs. Under the development plan Associated British Ports will build a £100 million deepwater berth capable of handling the new generation of large offshore wind developments. Siemens is already a leader in providing wind equipment in the UK with over 40% of the UK’s total onshore and offshore generating capacity generated by Siemens technology.
- Gamesa announced that it will base its turbine manufacturing base in Dundee as well as plans to plans to set up its offshore wind technology center in Glasgow, Scotland, creating ~130 jobs. Gamesa is also developing a Memorandum of Understanding with Scottish Enterprise, Dundee City Council and Forth Ports Plc for further developments in Dundee for manufacturing, logistics and operations and maintenance. This is conditional on the development of offshore wind projects in the area and the availability of sites for prototype offshore wind turbines. Gamesa’s offshore wind strategy for the UK includes construction of a wind turbine blade plant and offshore wind logistics from several UK ports.
- Key turbine manufacturers are establishing R&D and manufacturing facilities in the UK; in array design the UK has extensive capability and there are some strong UK developers such as Centrica.
- In July, 2011 it was announced that Gamesa will open a centre of excellence in Glasgow. With a strong heritage in marine engineering and a world-class skills market from the oil and gas industry, Scotland started from a strong base for offshore renewables.
- In June, 2011 a proposed turbine construction and operations base was put forward in the UK by RWE and Gamesa, adding fresh hope that the rapid-growth in the UK offshore wind market will result in local employment.
- Additionally Mitsubishi announced in December 2009 that it will spend up to £100 million over five years on an offshore wind turbine R&D centre in Edinburgh.
- Tata Steel announced in 2010 that it is investigating the option of developing a new facility to produce foundation strictures for offshore wind turbines in Teesside, potentially creating 220 jobs.
- A supplier of boat-landing systems, nacelle bedplates and transition decks to foundation structure manufacturers, MTL Group is an example of how the economic benefits from offshore wind farms can filter down the supply chain. A £250,000 UK Government grant enabled this company to redevelop a quayside site at the Port of Blyth – an area tipped to become a major hub serving the North Sea wind farms.
In May, 2011 General Electric also announced that it is planning to build a wind turbine factory in the UK and may combine it with a manufacturing plant by Converteam to create a wind energy ‘hub.’

While the establishment of these firms in the UK does not guarantee UK supply, it enables UK companies to compete with established suppliers.

Balance of supply costs are a lot higher for offshore wind projects, which need components such as foundations, substations and cables that are distinct from the requirements of onshore projects and which have fewer established suppliers, according to The Crown Estate. This means that committed UK companies have a chance of capturing a share of the home market.

**4b. Transmission Infrastructure and Supply Chain Solutions**

**Direct Funding**

- DECC’s approach to the supply chain is to focus on a small number of key constraints where they can have a particular impact, including the development of port sites. The Government has also committed £60 million for the development of wind manufacturing at ports and is committed to working with high-value added manufacturers to exploit supply chain opportunities.

- The Scottish Government are committing £70 million to enhance port and manufacturing facilities for offshore wind turbines in Scotland. This National Renewables Infrastructure Fund is intended to leverage private sector investment over the next 4 years and help to deliver ~£7.1 million in value to Scotland’s economy.

- In July, 2010 the Secretary of State announced £10 million in grants to the offshore wind industry with £5 million going to 7 UK firms with the intention of increasing the UK domestic supply chain for wind and creating jobs. Companies such as Hartlepool-based JDR Cables – who provide offshore wind transmission cables – and Rugby-based Converteam, a DC conversion technology firm were among those that received funding.

Changes to the Transmission Grid will help to overcome issues of wind intermittency and help to integrate renewable sources more effectively:

**Offshore Transmission Coordination Project**

- To improve investment planning, the Government announced the Offshore Transmission Coordination Project in March, 2011 to review incentives for coordination to ensure coordinated development of Round 3 offshore transmission assets. It aims to develop long-term position on security requirements for grid connection.

- The project is due to report at the end of 2011, followed by a consultation in 2012 if further measures are needed.

**Ofgem’s Role**

- Ofgem, the UK’s electricity and gas regulator, has been working with the UK Government to introduce a new regulatory regime for offshore power transmission. A key part of the regime is that offshore electricity transmission licences will be granted following a competitive Tender Process managed by Ofgem.

- The intention of the tenders is to ensure that new offshore renewable generation projects are connected to the British mainland electricity grid economically and efficiently.
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- Ofgem has put in place a regulated asset base and an offshore transmission operator regime that seek to provide an attractive and stable environment to incentivize long-term investment.
- The UK’s regime for the construction and operation of offshore transmission assets is designed to provide flexibility for generators in terms of who constructs the assets and cost-effectiveness to consumers.
- The UK Government and Ofgem have introduced the requirement for OFTOs to separate ownership of the wind farm generating assets from the electricity transmission assets to promote open competition, encourage innovation and bring in new technical expertise and finance. Generators have a choice of constructing the transmission assets themselves or to opt for an Offshore Transmission Owner (OFTO) to do so.
- If assets are constructed by the generators themselves the generator must transfer the assets to an OFTO post-construction and pre-operation. OFTO’s are selected on a competitive basis through a tender process.
- Ofgem estimates that the tender process will result in savings of £350 million to the consumer in relation to the first £1.1 billion of transmission assets tendered for Round 1 projects.
- Many developers are concerned that, if the OFTO has the responsibility for constructing the grid connection, they risk developing stranded assets with nowhere to plug them in.
- In addition, significant improvements in wholesale market liquidity are essential, to ensure a competitive market and promote long-term security of supply. Ofgem is working to address liquidity through its Retail Market Review.

Managing Intermittency - An Offshore Super Grid

- On December 3 2010, the UK signed a Memorandum of Understanding with 9 other European countries setting out a schedule for the development of an offshore electricity transmission grid with a network of North and Irish Sea sub-cables.
- All countries around the North Sea are important potential partners in a supergrid project, in particular, Germany, France, the Netherlands, Denmark, Norway and Ireland.
- A supergrid could represent a revolution in the scale and ambition of interconnection and offshore grid integration.
- The UK’s electricity system is the least interconnected of all European countries so a supergrid would enable countries to draw on shared resources and implies far greater interconnection.
- A main grid linking resources of Scandinavia and the rest of Northern Europe will mitigate the impact of variability of power output from renewable energy sources and will increase the ability of each national power system to accommodate the variability of offshore wind power supplies.
- Such a grid is also about integrating offshore renewable generation into the transmission system in order to optimize the output of technologies such as offshore wind and future marine projects. Currently offshore wind projects are connected to the onshore system individually by ‘radial’ or ‘point-to-point’ connections. A supergrid would integrate these connections into the transmission system itself reducing the need for new connections and enabling more efficient sharing of resources.
- Offshore wind farms will have capacity factors of between 30-45% but offshore wind farm grid connections have to be rated at near the maximum rating of the offshore wind farm. This leaves up to 60% of the offshore grid connection unused with a simple spur grid connection. By integrating the offshore wind farm grid connections with interconnectors, when the offshore wind farms are not generating at rated output, the available capacity on the grid connections can be used to trade electricity and ancillary services. So then these cables can be used in all wind conditions and are expected to be used up to twice as heavily as conventional wind farm connections.
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- According to the National Grid, an integrated network for the UK’s offshore wind delivery could provide a 25% discount for the UK consumer on the capital cost compared to connecting each offshore wind farm with a dedicated radial connection.
- Through integrating the offshore wind farm grid connections with interconnectors, when the offshore farm is not generating at full rated output, the available capacity on the grid connections could be used to trade electricity and other services.
- Technically a HVDC based offshore supergrid would not entail major risks. However, uncertainties in relation to procurement rules, regulatory frameworks and trading arrangements may result in risks to the success of a supergrid.
- Such a grid would however carry a high cost to develop. Estimates suggest that a supergrid could cost up to $28 billion and as the offshore supergrid would most likely be a regulated asset, the consumer will ultimately pay for it.
- Consideration of the benefits of job creation that would come from such construction as well as the economic opportunity of the UK being able to export power to Europe needs to be considered when evaluating cost effectiveness and communicating these advantages to consumers is vital to get buy-in and reduce backlash.
- The overarching point here is that the future of the power transmission system in the UK must be considered in the context of the Government’s renewable energy objectives. If the Government is to deliver its aspirations it will be necessary to develop a transmission system commensurate with the scale of offshore renewable expected.
- A more efficient way of connecting wind needs to be planned for offshore wind. It makes sense to make such investments ahead of capacity being developed, which means planning for a meshed grid in the next 2-3 years.

Other Methods of Balancing the Grid with More Intermittent Sources

- The low-carbon technology that could be deployed during the course of this decade has high capital costs and is only able to generate intermittently. This means that the system will need flexible capacity that is able to respond to demand spikes or shortfalls in supply. While thermal plant will be needed to provide reliable generation, the system will also call upon new technologies such as demand side response, storage and interconnection to fulfill this role. These flexible resources can offset intermittency and meet demand spikes, ensuring that the overall system resilience is maintained.
- Interconnectors are physical links between the UK and other electricity grids that allow electricity to be imported or exported according to price signals. The UK currently has 2.6 GW of interconnection, representing ~3% of peak demand. Trade across interconnectors can enhance security of supply. Interconnection has an important role in the future in enabling cost effective integration of low carbon energy by allowing for export/import at times of high/low renewable output.
- Demand side response involves shifting demand patterns to facilitate balancing of supply and demand. The Government anticipates an important role for DSR in the future to assist system balancing and reduce costs.
- Power storage also plays an important, but currently limited role in balancing the electricity grid. Storage involves storing electrical energy in other forms when supply exceeds demand and reproducing it as electricity when the system needs it. Installed storage capacity in the UK is currently around 3 GW, predominantly consisting of hydro pumped storage. But storage will be vital in the future as it can capture energy generated by inflexible low-carbon sources and reproduce it at times of need, irradiating some of the disadvantages of intermittency.
Skills shortages are a potential challenge to the development of the UK offshore wind industry. Round 2 offshore wind farms did not carry significant skills issues, however the more challenging environment for deployment of Round 3 projects may change this.

5. SKILLS

5a. Skills Challenge

- A successful offshore wind supply chain has the potential to sustain many jobs in the UK as previously discussed; however it can only do so if there are the skilled workers available.
- Round 2 wind farms were not associated with significant skills issues except for some specialist roles. Skills issues are however anticipated by employers as part of Round 3 development and deployment including planners, environment impact assessment specialists, engineers, cable jointers and project managers.
- According to the Crown Estate, skill shortages is a potential bottleneck to the offshore wind industry as the industry needs people with skills beyond that of the traditional power sector. For instance it needs those with experience of working at sea.
- The Crown Estate published a careers guide for young people in partnership with RenewableUK and BVG Associates to stimulate awareness of the range of future job opportunities and the skills requirements of the sector.
- There are various skills challenges in the UK facing the offshore wind sector:
  - Vacancy levels are driven by a lack of experience, a lack of qualifications and a shortage of applicants. There is a lack of people in the UK with electrical and power industry knowledge;
  - There are skills gaps in engineering areas which will be exacerbated by the rapid expansion of offshore wind;
  - Installation managers are in short supply;
  - Geographic access to skills and jobs can be hard in the onshore sector and will be a greater issue for the offshore sector.
  - The education and training infrastructure have a large role to play in ensuring the right people are available in the right place and at the right time. Funding issues are a problem for universities.
  - There is a need to prioritize support for the energy sector in general with a particular emphasis to be placed on offshore wind.
- The areas where recruitment was reported to be particularly hard were managerial, professional and associated professional jobs; and job roles relating to project managers, technical sales people and those able to carry out EIA’s offshore, according to a Cambridge Econometrics (2011) survey.
- Some of the reasons behind skills shortages include a shortage of graduates specializing in electrical and mechanical engineering and design, as well as shortages in project management skills in the marine environment. Sector attractiveness in terms of tough working conditions and the low esteem in which construction, manufacturing roles are held is also an issue.
- Many of the skills needed in the offshore wind industry are also required in other parts of the energy industry. The training and education infrastructure supporting the industry is fragmented, with too many disparate bodies working in isolation and new bodies being created, according to the Royal Academy of Engineering.
- The former Government set up a National Skills Academy for Power to work with regional clusters of training providers. However the Academy was criticized in the House of Commons Environmental Audit Committee’s December 2009
II. UK Offshore Wind – Challenges and Solutions

The committee concluded that the skills gap still represents a major barrier to UK success in environmental markets.

- Without changes to the labour force, the UK could risk missing out on the chance to match up growth in its renewable energy sector with regional redevelopment in areas of highest unemployment.
- The main impacts of skills shortages for the offshore wind sector are likely to be: delays in the speed at which development is able to occur, with shortages in one stage of the project development process having knock-on effects through delays in the next stages; higher labour costs and/or the need to introduce labour from elsewhere in the EU; the import of goods/export of fewer goods than would otherwise be the case where shortages occur in tradable products and services.

5b. Skill Shortage Solutions

- There are short term solutions to the skills gap in the offshore sector which include the supply of labour from other sectors, including offshore oil and gas, aerospace and the military. The Carbon Trust has stated that 15% of oil and gas jobs related to mechanical, electrical and marine engineering and construction and represented a potentially available workforce of ~40,000.
- Many of the elements needed to develop an offshore wind project have already been developed by the oil and gas sector in the North Sea such as installation, risk management, personnel transfer and operational and maintenance activity as seen in Exhibit 32. High potential opportunities include:

**Exhibit 32: Synergies between oil and gas industry and offshore wind**

<table>
<thead>
<tr>
<th>Development services</th>
<th>Expertise already exists in managing offshore construction from concept to production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support structures</td>
<td>There is existing capability to manufacture ancillary components and deep sea structures</td>
</tr>
<tr>
<td>Offshore substations</td>
<td>There is already oil and gas expertise in detailed design, fabrication and project management. Many of the challenges of designing and fabricating offshore wind farms are shared with offshore substations.</td>
</tr>
<tr>
<td>Support structure installation</td>
<td>Large offshore construction contractors have based in Scotland and have major construction assets at their disposal.</td>
</tr>
<tr>
<td>Array cable lay &amp; export cable lay</td>
<td>The oil and gas sector has leading capabilities to lay and bury cables – one of the areas that is perceived by wind developers, insurers and financiers as a high risk in the installation phase of a project.</td>
</tr>
<tr>
<td>Replacement equipment</td>
<td>This is an excellent area for skills transfer. The oil and gas sector already operates a large service and logistics operation covering the North Sea region.</td>
</tr>
<tr>
<td>Skilled technicians</td>
<td>Inspection and repair activity is high within the North Sea sector with a high number of skilled and experienced technicians.</td>
</tr>
<tr>
<td>O&amp;M ports</td>
<td>Ports around Scotland have been playing a vital role in the development and upkeep of North Sea oil and gas assets. A number of locations with deep water facilities could be potential construction bases for offshore wind.</td>
</tr>
</tbody>
</table>

II. UK Offshore Wind – Challenges and Solutions

- There are clearly various market opportunities for the oil and gas supply chain in the offshore wind sector which could help to alleviate some of the skill shortage issues in the future and also will help to build a domestic supply chain. In late 2010, in recognition of the potential for the transfer of experience, a Ministerial Summit was held in Scotland to bring together senior leaders from the offshore wind and oil and gas sectors to discuss issues around collaboration to maximize the opportunities that will arise from offshore wind development.

- However there are issues with relying on oil and gas workers to supply the workforce for offshore wind and these include wages and benefits being far lower in the renewable sector; an ageing workforce; and demand for recruits in oil and gas for decommissioning activities in the North Sea.

- In the medium term, apprenticeships are seen a key source of skilled labour. EU Skills and RenewableUK have developed a bespoke Modern Apprenticeship in Wind Turbine Operation and Maintenance to provide a structure for training those interested in working in the wind energy industry.

Dedicated Courses

- The Department for Business, Innovation and Skills launched the low-carbon skills consultation in March 2010 outlining plans for 3500 co-funded apprenticeships, with 2500 in the wind sector. Such regional schemes are valuable but need to be linked to a national strategy, which is currently lacking in the UK.

- A multi-million renewable energy centre at the Grimsby Institute is to become the first of its kind in the world to train the next generation of offshore wind engineers. The centre will offer full and part time renewable energy engineering courses as well as apprenticeships based in the production and maintenance of offshore wind farms.

- The Government should look to encourage competence-based qualifications and accreditations applicable across the energy industry. Energy-wide frameworks and qualifications could rectify this.

- Building awareness of the renewable energy industry and opportunities on offer among teachers, careers advisers and students will encourage people to consider energy as a career choice.
III. UK Offshore Wind – Concluding Remarks

The UK faces an energy challenge. An estimated 21 GW of conventional power capacity will need to be retired by 2025 due to an aging fleet or non-compliance with European emission directive’s, representing around 25% of the current UK power generating capacity. The UK Government recognizes the need to achieve these shifts in its energy supply mix in order to meet its GHG emission mandates, and make the country more energy secure.

Owing to the country’s excellent offshore wind resource, the sector is seen as offering the most sizeable contribution towards the UK’s 15% renewable energy target by 2020. Scaling up offshore renewable energy power generating capacity can tie into the Government’s regional and economic development policies by creating employment opportunities for up to 70,000 people and helping to regenerate former manufacturing regions of the country.

The investment opportunity is also clear. The UK needs between £200-£550 billion of investment in low carbon energy and transmission systems by 2020 to meet its clean energy targets, and The Crown Estate estimates that delivering the Round 3 offshore wind farm pipeline necessitates ~£100 billion in capital investments, based on current offshore costs of £3m/MW. Opportunities exist in creating a robust domestic offshore wind supply chain, in new power network capacity, in technological innovation and in improving domestic infrastructure such as port facilities and international grid networks to support increasing amounts of renewable power.

However alongside this potential for offshore wind there are some very significant challenges to overcome if the UK is to achieve its aim of 18 GW of installed offshore wind capacity by 2020. The foremost challenges are to drive down costs within the sector and improve access to finance. Unlike most other renewable energy technologies, offshore wind costs have increased substantially in the last 5 years. Uncertainty remains regarding the exact costs of the Round 3 leasing phase but they are widely accepted to be higher than Round 1 and 2 projects owning to construction in more challenging deeper sites, further offshore. The Committee on Climate Change warns that unless costs are reduced, only 13 GW of offshore wind can be realized by 2020.

Low deployment of offshore wind to date, relative to the resource potential, has also been attributed to financing difficulties at the pre-construction phase, along with lengthy planning delays. Kick starting investment with targeted financial support during the construction phase via products on offer from the UK Green Investment Bank will be a vital support to the industry. Round 3 development zones assume fast development and construction rates and for this to happen, the domestic supply chain must also be capable of intense growth. Bringing more of the supply chain into the UK offers benefits in terms of reduced exposure to currency fluctuations as well as helping to build a green manufacturing economy and create domestic jobs.

DBCCA views the UK as a leader in providing Transparency, Longevity and Certainty (TLC) in its energy and renewable policies. The Government has supported the offshore wind sector via the Renewable Obligation since 2002, which has had success in helping the UK reach an installed capacity of ~1.5 GW of offshore wind. However, relative to the country’s resource potential this is still a very small installed capacity and represents a tiny fraction of the overall UK installed power base. In implementing the Electricity Market Reform and amending the Bands for the Renewable Obligation, the Government has recognised that this low deployment along with the previously mentioned challenges of cost and access to finance negates a change in the regulatory regime for large-scale renewables in the UK. We view the new regulatory structure as a positive for the UK offshore sector as the FiT CfD should offer more certainty over revenue and as it is considered more efficient in terms of cost should help to encourage longevity. What is crucial is that the transition to a FiT CfD needs to be a fully documented process and it must be ensured that there is a strong legal framework in place for the new FiT CfD and that it cannot be altered dramatically at a later stage.
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