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Value breakdown for the offshore wind sector

A report commissioned by the Renewables Advisory Board

February 2010

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Contents

1. Introduction

This report for the Renewables Advisory Board (RAB) by BVG Associates presents the results of a short study into the costs of offshore wind and the relative cost of labour, materials and other items expected in 2015.

The costs of offshore wind have been split into the following five clearly defined categories, plus up to two levels of sub-categories under this:

1. Development and consent
2. Turbine excluding tower
3. Balance of plant
4. Installation and commissioning
5. Operation and maintenance

Split of costs between the categories and sub categories and splits of labour, materials and other costs were given or derived from information provided by key industry players for their core area of activity at the request of DECC's UK Renewables Service. Where appropriate, these were combined and rationalised into the defined categories and sub-categories.

It is important to note that the split of costs for projects constructed in 2015 (ie. earliest Round 3 projects) will be different from existing wind farms. The categories which are expected to see the most change are:

(A) Supply and installation of offshore substations. Historically, offshore wind farms have been of a relatively small capacity (typically 90MW) and close enough to onshore grid nodes that they have not needed offshore substations. The first UK offshore wind farm to have an offshore substation was the 90MW Barrow offshore wind farm which came online in 2006. In 2015, all new commercial wind farms will need offshore substations and the breakdown presented here reflects this 2015 cost split.

(B) Supply of foundations. To date, wind farms have been installed in water depths generally of less than 20m. By 2015, average depths will be approaching 30m, with significant increase in cost.

Note In addition that limited data seen for specific wind farms has noticeable variations due to many technical factors such as basic design parameters like water depth, tidal range, metocean conditions, wind farm and turbine size, distances to grid connection point, nature of grid connection and distance to construction port. Even more significant have been market factors of commodity prices, demand for turbines and other resources and risk allocation via contracting strategies. There are also costs whose levels the industry is still learning such as those for Operation and Management, where the basis for costs for turbines installed far from shore in 2015 could be quite different to today.

2. Background

Offshore wind is expected to make the single biggest contribution to renewable energy generation in 2020 - the Renewable Energy Strategy (RES) Consultation projected 14 GW of installed offshore wind UK capacity producing 47 TWh in 2020. Currently, UK offshore sites with a combined capacity of 40 GW are being licensed. The Government is developing a range of measures to ensure that these levels of deployment can be achieved. The investment required by the market is substantial, covering a wide range of industries and services. Government is keen to see UK business benefit to the maximum extent from the opportunities, and to ensure that all elements of the supply chain develop in step to enable achievement of the deployment targets. RAB wishes to support the Government programme by helping to quantify the magnitude of the investment that will be required and its breakdown into individual elements of the sector.

3. Definitions

There are various forms of contracting the installation, operation and maintenance of wind farms and these treat the supply of hardware and services differently, in some cases hiding the true allocation of cost. As examples, cost and risk allocation between the supply and installation elements of an EPC contract is not visible to the wind farm developer and OPEX for the initial years of a wind farm often cannot be separated from CAPEX payments made to a turbine manufacture as part of a warranty agreement.

Strict definitions of the categories of costs of an offshore wind farm were applied here to best ensure the relative split between categories was consistent. Frequently in dialogue, however, interviewees were not themselves sure of the categorisation. These categories are as follows:

Development and consenting includes the multifaceted process of taking a wind farm from inception through to the point of financial close or commitment to build, depending on the contracting model, including Environmental Impact Assessment, planning, FEED studies and contract negotiation.

Turbine excluding tower includes supply of all components (including turbine transformers) upwards from (but excluding) the transition piece/foundation and in this case also excluding the tower structure. This includes delivery to a port (which may not be the port used for storage and pre-assembly of components before transfer to the wind farm site).

Balance of plant (BoP) includes detailed infrastructure design and supply of all parts of the wind farm except turbines, including tower, foundations, buildings, electrical systems between turbine and the onshore demarcation point between the wind farm and grid. Conventionally, the tower is seen as part of the scope of supply of the turbine. In this case, due to the synergies of manufacture of the tower and typical steel foundation, it has been incorporated here.

Installation and commissioning includes installation of turbines and balance of plant on site and commissioning of these to a fully operational state, up to point of issue of any take over certificate.

Operation and maintenance (O&M) starts from take-over, on completion of building and commissioning of all or part of a wind farm. It includes servicing of turbines and other parts including electrical grid connection. Whilst it does include insurance for the replacement of faulty/broken components or defective work it does not include coverage of this by warranties.

In addition, the following definitions are used:

Capital Expenditure (CAPEX) includes all one-time expenditure associated with wind farm development, deployment and commissioning up to the point of issue of a takeover certificate.

Operating Expenditure (OPEX) includes all expenditure occurring from immediately after point of takeover, whether one-time or recurring, related to the wind farm, measured on an annual basis. Excluded are expenses inherent to the operation of the operators business but not directly related to the operation and management of the wind farm.

Grid connection includes the dedicated cables and other costs associated with connecting the wind farm to the National Grid, including any isolators and switchgear under the control of the onshore network operator.

Warranty means a provision in contracts funded by CAPEX for the replacement of faulty/broken components or defective work, plus any agreed reimbursement due to consequent loss of revenue, usually for initial fixed periods which may vary for different elements.

Labour means direct & indirect labour, including UK office staff and supply chain staff contribution that could be realistically be in the UK given appropriate industry and market conditions. No judgement is made herein about what percentage of available jobs may be secured for the UK. Definitions of direct labour vary between organisations. In this document we do not differentiate between direct and indirect labour.

Materials means raw materials and components, consumables, equipment, plant and buildings plus labour associated with their supply that is unlikely to be in the UK. An example of this is the labour associated with mining of a non-UK ore.

Other costs include services (e.g. vessels, cranes), insurance, and other overheads. It does not include profit, taxes, debt servicing, or other expenses inherent to the operation of a business but unrelated to production. These expenses are assumed to be split in proportion with cost over all other costs incurred.

Note that due to uncertainties in methods and costs, revenues from recycling and the impact of repowering, net decommissioning costs, anticipated to be relatively low, are not considered. Project management, insurance and other costs relevant to many activities across the life of the wind farm have been included in these activities, rather than been separated out.

Data from a range of sources has been used, including from both specific installed and planned wind farms. Adjustments have been made in order to give representative results for a 500MW+ wind farm of approx. 5MW turbines on jacket foundations in typical UK east coast conditions around 80km from shore in water depth 30m and considering market dynamics prevailing at the start of 2010.

4. Typical offshore wind CAPEX and OPEX

Offshore wind CAPEX has been observed to rise to about £3m/MW in 2009[1] and is expected to fall gradually with the improvement in market conditions for turbines (onshore costs down by 25% over the last 18 months), maturing of existing processes and deployment of new technology in greater quantities, such that average CAPEX is likely to be around £2.5m/MW over the period to 2020, expressed in 2010 terms and assuming 2010 commodity prices.

Ernst & Young[2] in early 2009 derived generic figures of CAPEX= £3.2m/MW; capacity factor 38%; and OPEX £79k/MW/yr (excluding decommissioning). This equates to an OPEX of £24/MWh.

Offshore Wind OPEX published for North Hoyle, Scroby Sands, Kentish Flats, and Barrow as part of the DTI Offshore Wind Capital Grants in years 2 and 3 of their operation ranged from 11.3 to 15.2 £/MWh, but the scope of costs included during the warranty period is unclear. Ongoing survey work by DECC's UK Renewables Service suggests that £17-20/MWh may be typical.

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[1] *UK Offshore Wind: Charting the Right Course, Scenarios for offshore capital costs for the next five years*, BWEA, June 2009

[2] *Cost of and financial support for offshore wind, a report for the Department of Energy and Climate Change*, April 2009, URN 09D/534.

5. Survey results

The CAPEX and OPEX cost breakdowns, also considering labour, materials and other costs given below, followed by a consideration of R&D expenditure.

5.1. CAPEX

5.1.1 All CAPEX

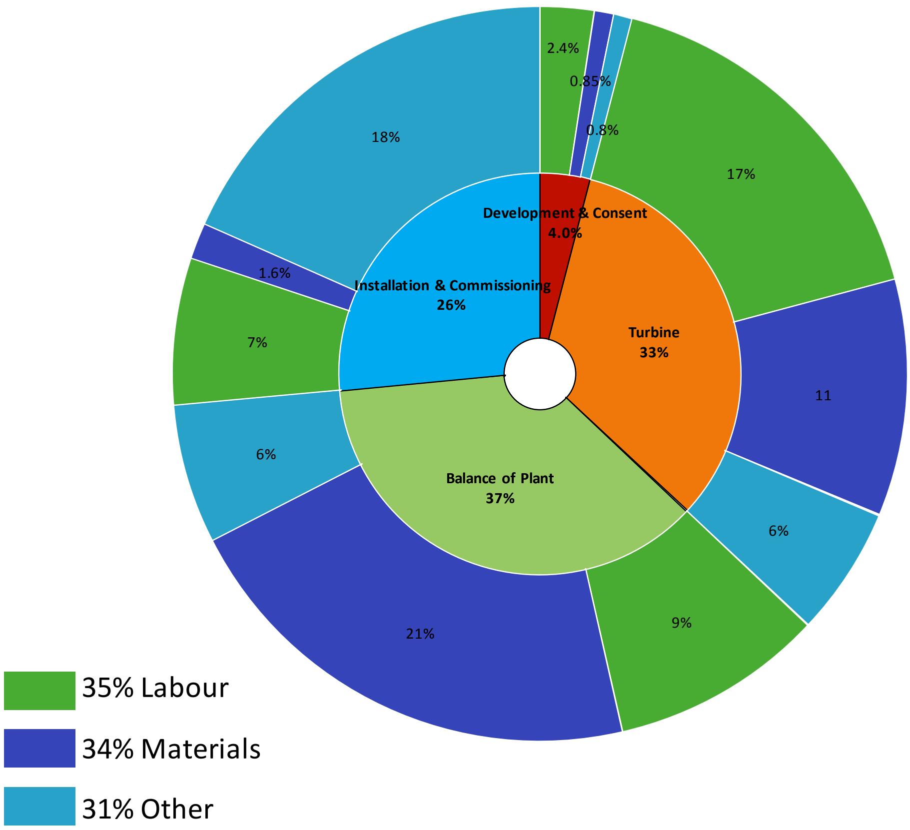

Figure and Table 1: Offshore wind farm CAPEX cost breakdown

Category	Category cost	Category component	Category component cost	Overall component	Overall component cost
Development & Consent	4%	Labour	2.4%	Labour	35%
		Materials	0.9%		
		Other	0.8%		
Turbine	33%	Labour	17%		
		Materials	10%	Material	34%
		Other	6%		
Balance of Plant	37%	Labour	9%		
		Materials	21%		
		Other	6%	Other	31%
Installation & Commissioning	26%	Labour	6%		
		Materials	2%		
		Other	18%		
TOTAL (%)	100%		100%		100%

Overall, we see that for a typical offshore wind farm, costs are relatively evenly distributed between turbine, balance of plant and installation and commissioning. This is in marked contrast to the distribution for onshore wind where the turbine ex-factory makes up around 70% of the total.

Likewise, labour, material and other costs are evenly distributed, but the dominant contribution to labour costs comes from wind turbine supply. Access to these jobs is discussed further below.

Each of the five categories is considered in more detail below, addressing key points under the headings of cost variation and drivers, bottlenecks and UK perspectives.

5.1.2 Development and consent

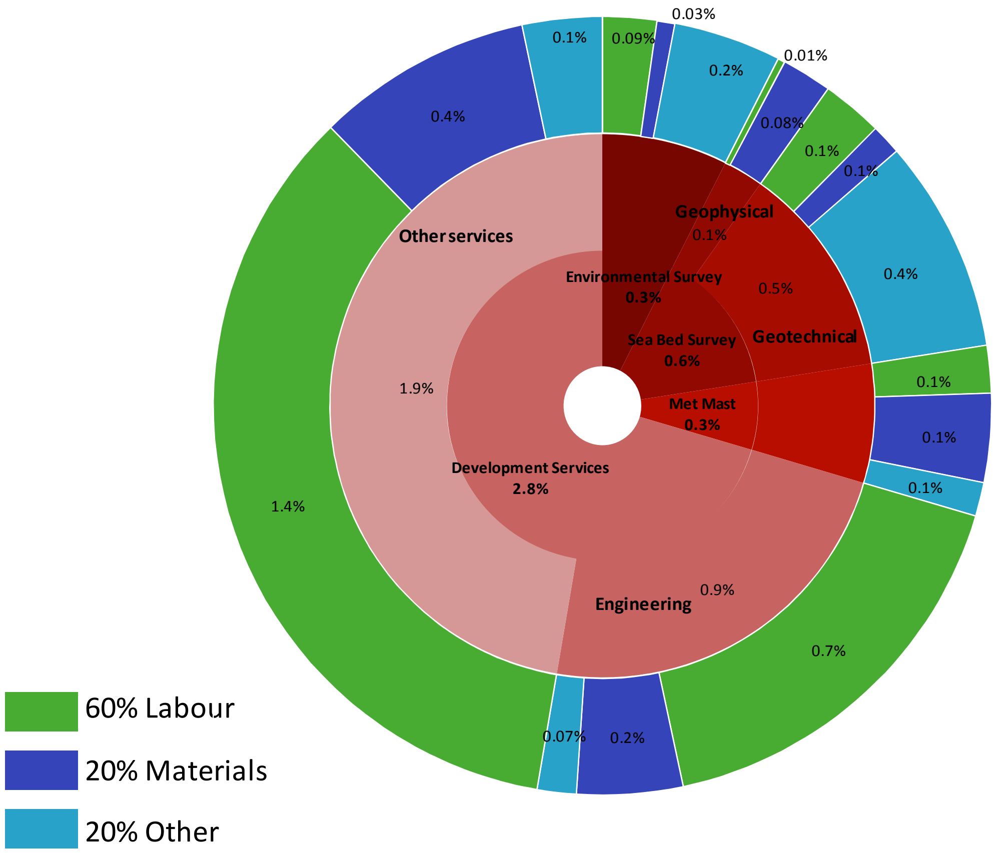

Figure and Table 2: Development and consent CAPEX cost breakdown

Category	Category cost	Sub-category	Sub-category cost	Sub-category	Sub-category cost	Sub-category component	Sub-category component cost	Category component	Category component cost
Development & Consent	4.0%	Environmental Survey	0.3%		0.3%	Labour	0.09%	Labour	2.4%
						Materials	0.03%		
						Other	0.2%		
		Sea Bed Survey	0.6%	Geophysical	0.1%	Labour	0.01%		
						Materials	0.08%		
						Other	0.00%		
				Geotechnical	0.5%	Labour	0.1%	Materials	0.8%
						Materials	0.05%		
						Other	0.4%		
		Met Mast	0.3%		0.3%	Labour	0.08%		
						Materials	0.1%		
						Other	0.06%		
		Development Services	2.8%	Engineering	0.9%	Labour	0.7%	Other	0.8%
						Materials	0.2%		
						Other	0.07%		
				Other Services	1.9%	Labour	1.4%		
						Materials	0.4%		
						Other	0.1%		
	4.0%		4.0%		4.0%		4.0%		4.0%

Cost variation and drivers

Development and consenting costs per MW installed are significantly affected by scale of the wind farm. As an example, the development cost of installing a met mast may be shared over 25 turbines on a small wind farm close to shore and over 100 turbines on a large wind farm further from shore where variations in wind conditions across the wind farm are much reduced. Some costs are likely to rise significantly – for example some environmental studies cannot be carried out 100 miles from shore in the same vessels or using the same aerial method as used when only 10 miles from shore, due to practical and health and safety considerations.

Overall, there is a fair degree of uncertainty relating to cost breakdown and labour content due to the fragmented nature of the activity and a fast pace in development of process for carrying out key activities as the pool of available knowledge grows.

Bottlenecks

Due to the fact that so many development consortia are looking to accelerate development and consenting activities simultaneously for Round 3, bottlenecks in supply of key services are likely to be seen. Other later categories of activity will not suffer so much from this situation. Many also anticipate that limited resources at statutory consultees may also cause delay to development programmes for some.

UK perspectives

Development and consenting has fairly high labour content and much of the work is well suited to be carried out within the country of development of the wind farm, due understanding of legislative and other operating frameworks, convenience of language, continuity with installation and operating activities and access to local supply chain. Many small companies play an important role in providing expertise and equipment.

The opportunity for influencing the location of labour and creation of UK jobs is relatively low, though it is recognised that there is a strategic opportunity for UK companies to both to export experience and influence supply chain decisions for subsequent higher-value activities due to the fact that so much more wind capacity has now been installed in the UK than in any other market.

Encouraging clustering is likely to accelerate learning which has the potential to drive out costs during wind farm construction as well as in the development and consenting phase itself.

5.1.3 Turbine excluding tower

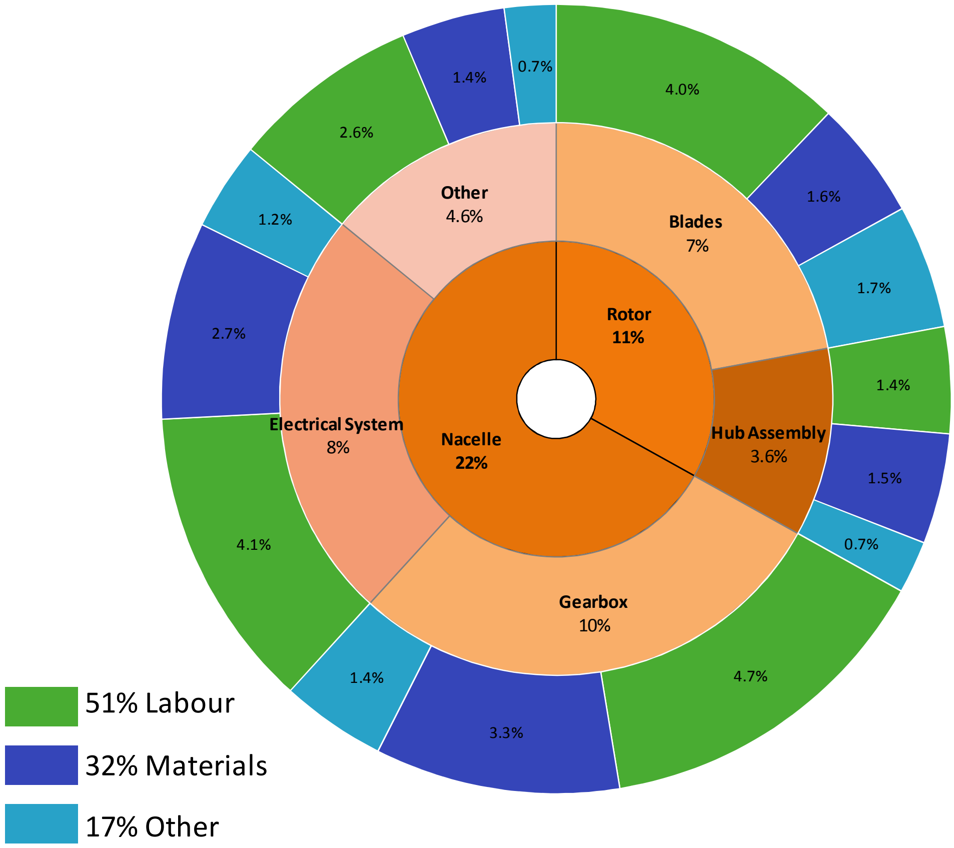

Figure and Table 3: Turbine excluding tower CAPEX cost breakdown

Category	TOTAL Percentage lifetime cost (%)	Component	Component Percentage lifetime cost (%)	Sub-component	Sub-component Percentage lifetime cost (%)	INDIVIDUAL Labour, Materials & Tooling	INDIVIDUAL Percentage lifetime cost (%)	CATEGORY Labour, Materials & Tooling	CATEGORY Percentage lifetime cost (%)
Turbine	33%	Rotor	11%	Blades	7%	Labour	4.0%	Labour	17%
						Materials	1.6%		
						Other	1.7%		
				Hub Assembly	3.6%	Labour	1.4%		
						Materials	1.5%		
						Other	0.7%	Materials	10%
		Nacelle	22%	Gearbox	9%	Labour	4.7%		
						Materials	3.3%		
						Other	1.4%		
				Electrical System	8%	Labour	4.1%		
						Materials	2.7%	Other	6%
						Other	1.2%		
				Other	4.6%	Labour	2.6%		
						Materials	1.4%		
						Other	0.7%		
	33%		33%		33%		33%		33%

Cost variation and drivers
Variations in turbine costs are dominated by market dynamics, both at a wind industry level and a commodity level.

Recent analysis suggests that on average wind turbine prices have dropped by 25% in the last 18 months. In the three years prior to this, offshore turbine prices increased by almost 50%. Prediction of future market dynamics is difficult, but today the market has a far wider reaching supply chain and many more wind turbine manufacturers than at the peak of the market between 2004 and 2008. This should mean both greater ability to respond to increases in demand and tougher competition keeping prices even.

There has been a long history of reducing underlying CAPEX over time in the onshore wind industry, these dominated by turbine costs. The trend is due both to classic ‘learning theory’ effects of increasing experience and quantity of production and increase in scale of turbines as the availability of new technologies and materials have allowed. If this trend continues, then we will see a reduction in turbine cost of the order of 20% up to 2020.

Key commodities in order of material cost are fibreglass, mild steel, SG iron, copper and high grades of steel, these making up around 90% of the material cost of a turbine. The variability of steel prices over the last 3 years has been significant, with a more-than-doubling followed by a significant rebalancing. With many material prices being linked to energy prices, we are likely to face a period of high volatility in energy and hence commodity prices until fossil dependency is reduced.

Bottlenecks
In terms of component supply, we have moved from a period of significant shortage on a number of fronts to more localised bottlenecks, the tightest remaining large bearings. We are in a period of geographical change in the supply chain, with significantly increased capability coming on stream in the Far East and to a lesser degree in the US. This has decreased the export of components from the EU and hence in some cases has led to an overcapacity in the EU for supply to the EU. Some suppliers have taken action, for example Vestas closed EU facilities at the same time as extending US and Chinese production. It is important to remember, however, that with a global doubling of supply every four years or so, this overcapacity will soon be used up.

Two years ago, many had concerns about the likely availability of sufficient turbines suitable for the offshore wind environment and sufficient suppliers to constitute a competitive environment. Our knowledge-based forecasts then of the number of turbines that will be available and number players that will have established pedigree in the market were seen as encouraging. Today, we are further encouraged by the focus being given to offshore wind by another tranche of significant onshore players, a number of which have not yet made public their plans for the offshore wind market.

UK perspectives
Another key consideration for offshore turbines is that much of the supply capacity for large components and nacelle assembly is inland, where logistics for very large turbines will have a major impact on long-term viability. Right across the supply chain, there is a need for coastal facilities to serve efficiently the offshore market and the UK is well positioned to benefit from this growth.

Regarding labour, key UK-based first tier suppliers have advised a consistent picture that a significant percentage of their costs relate to labour, either in-house or throughout their supply chain. As in some cases the supply chains are quite deep, there is a fair degree of uncertainty in the estimates but the pattern received has been consistent.

Much of the labour content is accessible labour content in the supply of wind turbines and the key to unlocking this for the UK is attracting assembly of wind turbine nacelles. It has been demonstrated over the last five years that against an established local supply chain from the continent and tough new competition from the Far East, it is hard for competent UK companies to break in to the supply chain to wind turbine manufacturers.

The UK government is in advanced discussions with a range of wind turbine manufacturers about establishing coastal nacelle assembly facilities in the UK, in competition with other countries bordering the North Sea. Although the actual value and labour content of assembly of nacelles is low (less than 1% of total wind farm CAPEX), the opportunity that local assembly affords for all tiers of the supply chain is significant. The approach from turbine manufacturers to developing new sources of supply to newly located assembly facilities has varied, but generally it incorporates a process of importing compete kits then partial kits then only specific key components as the local supply chain establishes.

Today, the largest supplier of turbine components in the UK is Converteam, manufacturing power converters and direct-drive generators. David Brown has just won its first order for the manufacture of gearboxes and a range of other components are being (or could be with some investment) manufactured in the UK. Strategically important items include large SG iron castings, large steel forgings and large bearings.

5.1.4 Balance of plant

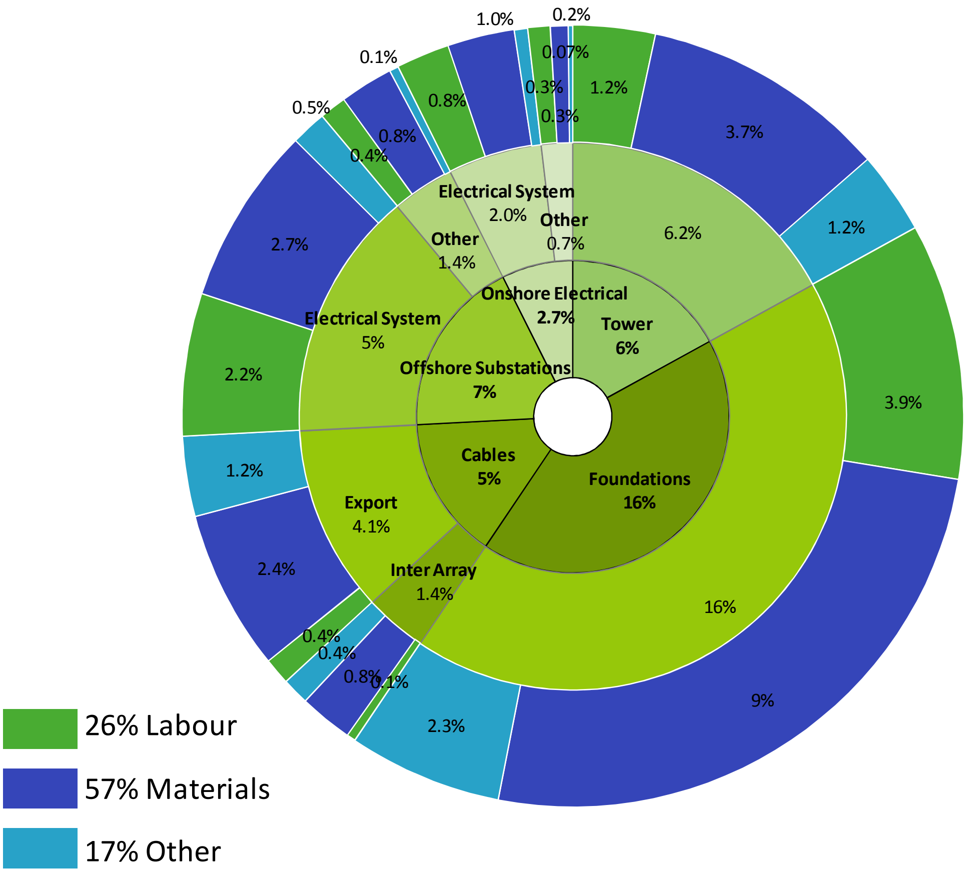

Figure and Table 4: Balance of plant CAPEX cost breakdown

Category	TOTAL Percentage lifetime cost (%)	Component	Component Percentage lifetime cost (%)	Sub-component	Sub-component Percentage lifetime cost (%)	INDIVIDUAL Labour, Materials & Tooling	INDIVIDUAL Percentage lifetime cost (%)	CATEGORY Labour, Materials & Tooling	CATEGORY Percentage lifetime cost (%)
Balance of Plant	37%	Tower	6%		6%	Labour	1.2%	Labour	9%
						Materials	3.7%		
						Other	1.2%		
		Foundations	16%		16%	Labour	3.9%		
						Materials	9.3%		
						Other	2.3%		
		Cables	5%	Inter Array	1.4%	Labour	0.1%		
						Materials	0.8%		
						Other	0.4%		
				Export	4.1%	Labour	0.4%	Materials	21%
						Materials	2.4%		
						Other	1.2%		
		Offshore Substations	7%	Electrical System	5%	Labour	2.2%		
						Materials	2.7%		
						Other	0.5%		
				Other	1.4%	Labour	0.4%		
						Materials	0.8%		
						Other	0.1%		
		Onshore Electrical	2.7%	Electrical System	2.0%	Labour	0.8%	Other	6%
						Materials	1.0%		
						Other	0.2%		
				Other	0.7%	Labour	0.3%		
						Materials	0.3%		
						Other	0.07%		
	37%		37%		37%		37%		37%

Cost variation and drivers
Foundation cost variation typically is dominated by steel cost variation and the impact of water depth and ground conditions on the design of the foundation. Other balance of plant costs are somewhat more stable.

Foundations provide both a significant contribution to the cost of an offshore wind farm and significant scope for innovation, especially for larger turbines and in deeper water where conventional offshore wind turbine foundations are not likely to be viable and methods of manufacture of jacket structures taken from oil and gas need to evolve significantly to be suitable for the quantities required for offshore wind. Complex dynamic issues at larger sizes will also drive new thinking.

The other main element of balance of plant costs is the electrical system, all of which is considered here even though the transmission links to shore will be owned and operated by separate companies to the wind farms themselves.

Technology development has a key role to play in impacting costs here as well. To date, power from offshore wind farms has either been brought ashore via an extension of the array cables (at say 33kV AC) or from an offshore substation via export cables (at say 132kV AC). In future as wind farms are located further from shore, point-to-point HVDC systems (using relatively well proven technology in other applications) will prove cost more effective. Looking further ahead, momentum is building for the creation of an offshore grid network which could itself be HVDC, though international consensus and new technology is required in order to implement such infrastructure that could have a significant impact both on the economics and also the potential market penetration of offshore wind.

Bottlenecks
Today, there are few suppliers of foundations for offshore wind and this is having an impact on cost. A number of players are investing – all coastally located - including in the UK. Our analysis suggest that although today there is insufficient supply capability to meet needs in (say) 2015 and that there may be periods where supply of foundations is tight, foundations are unlikely to be a bottleneck as time to bring on new plant is relatively short.

There is more concern about cable supply; especially high voltage AC or DC cables where the supply base is limited currently to 4 companies and time to establish new production facilities is significant. It is quicker to bring on new lines in existing facilities but still we see potential bottlenecks, depending on competition from other energy infrastructure projects, globally.

UK perspectives
Today, the UK has BiFab, the market leader in jacket structures, just being used for the first time in a commercial project. Ormonde offshore wind farm consists of 30 5MW turbines and is being constructed on the west coast, off Barrow-in-Furness. The UK also has a number of players in the advanced stages of establishing manufacturing facilities in coastal locations, also for monopiles.

The UK is home to strong engineering capability in electrical systems and many elements of offshore substations (including substructures) have been manufactured in the UK, though the largest transformers are not available. JDR Cable systems has recently established new coastal cable manufacturing facilities in Hartlepool and on the back of this has won orders for Greater Gabbard and London Array offshore wind farms, the first two of the large-scale UK Round 2 projects to be built.

There is no single solution to maximising UK benefit in balance of plant, but due to the size of structures and proximity of the market, as long as UK players receive support comparable to that provided on the continent, they should be well placed to compete.

5.1.5 Installation and commissioning

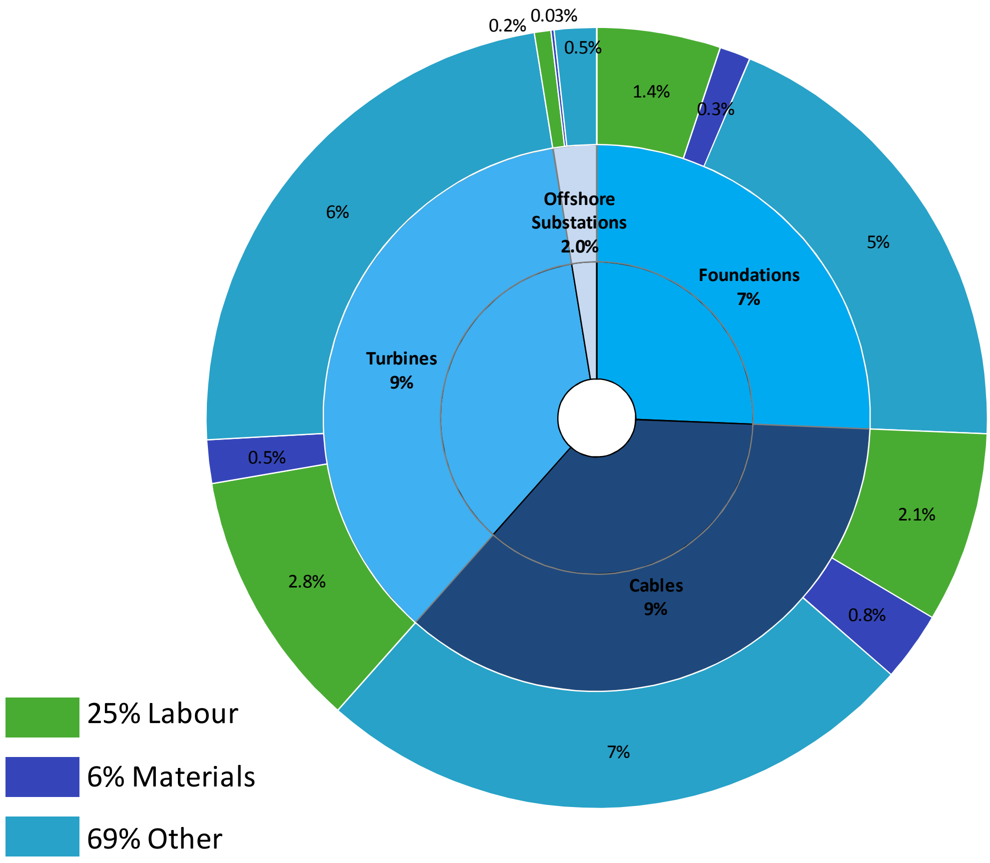

Figure and Table 3: Installation & Commissioning CAPEX Cost Breakdown

Category	Category cost	Sub-category	Sub-category cost	Sub-category component	Sub-category component cost	Category component	Category component cost
Installation & Commissioning	26%	Foundations	7%	Labour	1.4%	Labour	6%
				Materials	0.3%		
				Other	5%		
		Cables	9%	Labour	2.1%		
				Materials	0.8%	Materials	1.6%
				Other	7%		
		Turbines	9%	Labour	2.8%		
				Materials	0.5%		
				Other	6%	Other	18%
		Offshore Substations	0.7%	Labour	0.2%		
				Materials	0.03%		
				Other	0.5%		
	26%		26%		26%		26%

Cost variation and drivers

Installation costs are dominated by vessel chartering costs. These in turn are closely related to market dynamics. To date, for many projects the range of capable and available installation vessels has been minimal and so prices and risks of delay due to equipment failure or weather have been high.

New installation methods will also impact costs. We are seeing a move to the use of even larger, faster vessels for installation, allowing more turbines to be transported and installed in one trip, thus reducing time spent transporting hardware from manufacturing facilities. A competing method is the offshore transfer of hardware from feeder vessels to jack-up installation vessels, avoiding the need for these high-cost vessels to return to port to collect another batch of turbines. Another key opportunity looking forwards is the possibility to construct compete turbines on land and then install turbines and foundations in one operation, potentially reducing dependence on expensive vessels. For optimal solutions, foundation design needs to be considered in parallel with installation methods.

To date, installation of subsea cables has been characterised by cost overruns and in a number of cases, cable damage. Subsea cables have been the largest source of insurance claims in offshore wind to date. There is certainly room for savings due to more holistic consideration of cable design and installation requirements and methods.

Bottlenecks

A key concern from many offshore developers is the availability of installation vessels, especially for turbines. The combination of turbine size, mass and water depth in some cases has effectively limited supply to a single vessel. This dynamic is now starting to change, with a range of operators investing in new craft that are starting to come on stream. Investments are high (of the order of £100 to £150m for the next generation of vessel, but with many developers now having a significant portfolio of projects, we are seeing investment in new vessels from both wind farm developers and established and new operators.

The other area of potential bottleneck is skills, both at the design engineer / project management level and at the offshore technician level. It is recognised that different solutions are required for each and there will be competition with other countries for taking the significant employment opportunities will be created in this area. With long periods at sea, there is no strong driver for staff to be based local to the closest port to the wind farm, for example.

UK perspectives

Investment in purpose-built installation vessels is anticipated to be the single largest category of investment in manufacturing facilities and infrastructure (rather than wind farm CAPEX) that is needed in offshore wind. The UK has businesses that are thriving from manufacturing workboats but the industry believes that it is unlikely that large installation vessels will be manufactured outside of the Far East. Opportunities still exist for UK companies to provide significant hardware for these vessels, including propulsion and positioning systems. Such hardware could account for over 1/3 of vessel costs.

The UK also has a pedigree of excellence in offshore engineering and implementation, though traditionally with a different cost base in oil and gas. Careful planning is needed to ensure that sufficient training capability and resulting skilled staff are available to enter the competitive market in this area.

5.2. OPEX

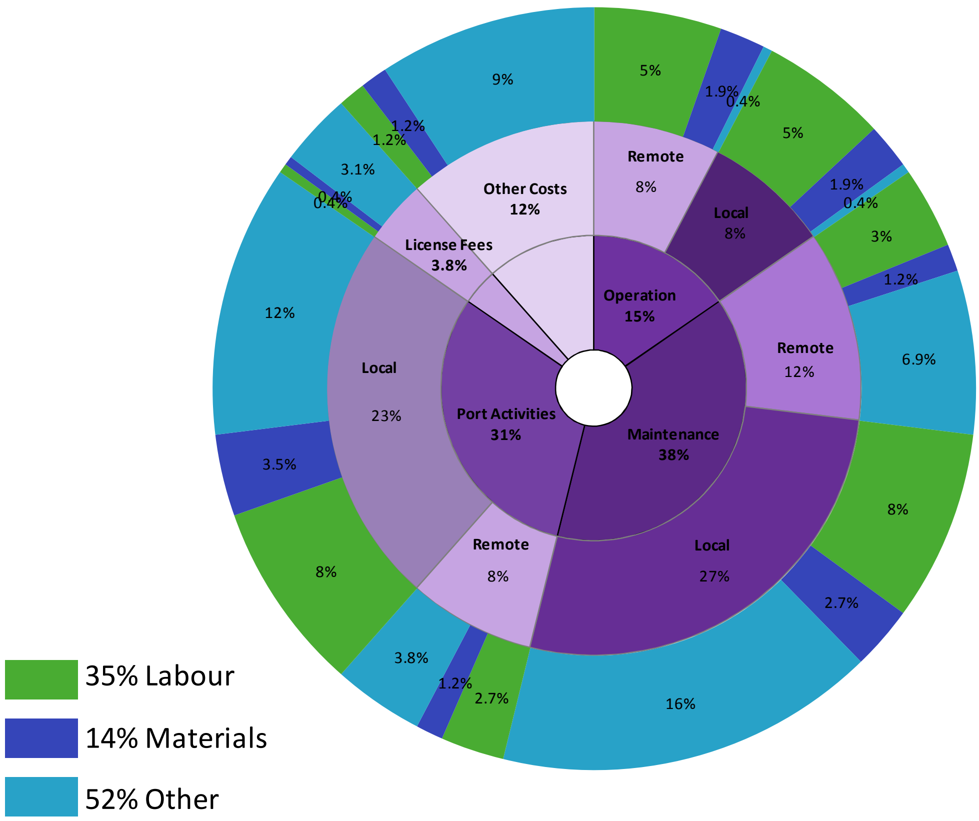

Figure and Table 4: Operation and Maintenance (OPEX) Cost Breakdown

Category	category cost	Sub-category	Sub-category cost	Sub-category component	Sub-category component cost	Category component	Category component cost
Operation	15%	Remote	8%	Labour	5%	Labour	35%
				Materials	1.9%		
				Other	0.4%		
		Local	8%	Labour	5%		
				Materials	1.9%		
				Other	0.4%		
Maintenance	38%	Remote	12%	Labour	3%		
				Materials	1.2%		
				Other	6.9%	Materials	14%
		Local	27%	Labour	8%		
				Materials	2.7%		
				Other	16%		
Port Activities	31%	Remote	8%	Labour	2.7%		
				Materials	1.2%		
				Other	3.8%		
		Local	23%	Labour	8%		
				Materials	3.5%	Other	52%
				Other	12%		
License Fees	3.8%		3.8%	Labour	0.4%		
				Materials	0.4%		
				Other	3.1%		
Other Costs	12%		12%	Labour	1.2%		
				Materials	1.2%		
				Other	9%		
	100%		100%		100%		100%

Cost variation and drivers
Long-term costs of operating and maintaining offshore wind farms currently are clouded by a series of expensive retrofits on early wind farms, invisible costs covered in the supply chain during warranty periods and politically-driven pricing of early service agreements as part of CAPEX costs. Costs of operating at great distances from shore are yet to be thoroughly evaluated within the industry, let alone demonstrated during the life of real projects. It is recognised by many that the cost base will affected by choices relating to location of service staff (onshore or offshore) and methods of transfer (large or small craft of helicopter), both with significant health and safety considerations.

Reliability (including advanced condition monitoring and failure avoidance), maintainability (including minimising need for use of jack-ups for repairs) and operations management (including condition-based maintenance techniques and scheduling of activity) are all receiving high focus.

Bottlenecks
No significant bottlenecks are envisaged due to the offset in when CAPEX and OPEX resources are required. Possible areas of concern relate to repair vessels required for large component replacement.

UK perspectives
To date, routine maintenance of near shore projects has been carried out from the nearest port with sufficient infrastructure (requirements are not onerous), with retrofit and repair of large components following models closer to those used during installation. Prospects are good for long-term jobs in direct operations and maintenance activities, with a number of possible contracting structures that could be adopted. The supply of repair services of critical components depends on warranty arrangements but for onshore wind has been a useful way of increasing application understanding prior to supply of new hardware.

Making some simple assumptions, we conclude that for offshore wind plant, of the order of 0.5 jobs/MW operated is created across the supply chain, that are available to UK workers. This of a similar magnitude to EWEA[3] estimate of 0.4 jobs/MW for onshore wind. EWEA anticipates a decline of the order of 20% in these figures by 2020 due to learning and efficiency savings.

5.3. R&D

Across all industries, UK R&D was 1.9% of GDP in 2009 and UKTI has a target to increase this to 2.4% by 2014. Assuming that it is typical of wind industry companies' turnover and that 30 GW of wind farm capacity at £2.5m/MW is built in the next 10 years then R&D of circa £50-60m/GW might be expected for the industry as a whole. Given the level of technical innovation circa 2% of turnover might be lower than expected so investment may approach £80m/GW.

We estimate that wind turbine manufacturers themselves spend of the order of £20m/GW on R&D and assuming they account for about 25% of the R&D in the wind industry with 25% done by their suppliers and a further 50% done in the rest of the offshore wind industry (foundations, electrical grid, etc) then this agrees with the £80m/GW derived above.

The UK content of this R&D expenditure is dependent on industrialisation of the supply chain and securing development projects in the UK, for example through continued support via DECC's ETF programme, ETI's Offshore Wind programme and Carbon Trust's Offshore Wind Accelerator.

[3] *Wind at Work, Wind energy and job creation in the EU* EWEA, January 2009.

6. Conclusions

For Offshore Wind in the UK:

- 35% of both CAPEX and OPEX costs are expected to be labour, including UK office staff and supply chain staff contribution that could be realistically be in the UK given appropriate industry and market conditions.
- The category of supply with the most labour is the wind turbine, where labour makes up 46% of its cost and contributes 18% to total CAPEX.

There is a significant opportunity for the UK to capture labour benefits from offshore wind and much work needed to secure this.

Making some simple assumptions, these figures equate to of the order of 18 jobs per MW installed per year across the supply chain during the period 2015-2020, that are available to UK workers. This of a similar magnitude to EWEA4 estimate of 15 jobs/MW for onshore wind and inferred 20-25 jobs/MW for offshore wind now, declining to 11 jobs/MW for onshore wind in 2030 due to learning and efficiency savings which if mirrored in offshore would equate to 17 to 21 jobs/MW in 2020. Through the whole of the supply chain, EWEA suggests offshore wind has around a third more jobs per installed MW than onshore.

For an annual offshore market of say 5GW, with cost of a job assumed to be £50k per annum including labour aspects of overhead, the capital expenditure equates to around 88,000 jobs which breaks down approximately as follows:

Category	Jobs/MW installed/yr	Jobs @ 1GW/yr	Jobs @ 5GW/yr
Development and consent	1.2	1,200	6,000
Turbine (excluding tower)	8.4	8,400	42,000
Balance of plant (including towers)	4.7	4,700	23,500
Installation and commissioning	3.2	3,200	16,000
Total	17.5	17,500	87,500

Following a similar process, for an installed base of 20 GW, O&M activities will provide around 9,000 jobs.

7. Recommendations

1. *Get wind turbine manufacturers to establish assembly in UK:*

- More than 50% of labour relating to CAPEX relates to the turbine. The majority of this is in turbine supply which will only open up to UK companies significantly if assembly of turbines by some of the main wind turbine manufacturers is established in the UK.
- Around 6 wind turbine manufacturers that are likely to play a significant role in offshore wind are currently considering location of facilities for assembly of offshore wind turbines – with some decisions this year, now that the playing field is established with Round 3 and Scottish Territorial Waters consortia developing supply and logistics plans for the build-out of their zones. Others have chosen elsewhere for first facilities. We should aim to bring at least half of these to the UK.
- To maximise UK jobs, we need to take a big-picture view of long-term benefit and provide support to ensure that at least three come to the UK via:
  - Provision of suitable coastal manufacturing locations (investment in quays, buildings and associated local infrastructure to provide sufficient 'draw' especially for those

[4] *Wind at Work, Wind energy and job creation in the EU* EWEA, January 2009, Page 9.

east coast sites seem as most suitable for industrial development by the wind industry).
  - Investment support for key elements of their supply chain (most of the infrastructure is needed by their supply chain rather than the wind turbine manufacturers themselves), encouraging clustering around the preferred east coast locations and maximising UK benefit from the developments both in UK and continental waters.
  - Investment in infrastructure to support technology development (on-land turbine demonstration sites for 5MW+ turbines plus state-of-the-art bench test rigs to test components and systems at offshore scale).
  - Cross-Departmental approach in engaging with these wind turbine manufacturers, recognising UK has competition for their presence from the continent.

2. *Support Industrialisation in turbine and balance of plant supply*
   - As well as in turbine component manufacture, significant jobs also exist in supply of balance of plant.
   - Having established a viable market for component supply (with the establishment of UK assembly) and in balance of plant supply, critical is to provide an environment that encourages investment to supply from UK, rather than overseas.
     - Many of enabling actions in 1 are relevant.
     - Also need ongoing tax incentive or similar to ensure that investment stays close to market (i.e. UK) and that UK manufacturing companies (traditionally more risk averse than continental companies in the wind industry) are enabled to invest.

3. *Grow stronger technology development infrastructure*
   - If we are to host the largest market in the world for offshore wind, then it is our interest to ensure that technology development is progressed as fast as possible in order to minimise lifetime cost of energy generated.
   - Infrastructure required includes dynamic workshop test facilities, such as the drive train facility planned for NaREC, onshore prototype and demonstration sites for very large offshore turbines and offshore sites for complete turbine and support structure demonstration.

4. *Mirror the PILOT taskforce that has worked so well for North Sea oil and gas.*

We have advocated for some time a similar approach for offshore wind that has been taken to address delivery and cost issues in the North Sea oil and gas sector. One aspect of this would be to grow a sense of identity for the offshore wind sector as it embarks on a programme of investment similar in magnitude to that of oil and gas. Another would be to introduce a supply chain code of practice and ongoing feedback such that dialogue and collaboration across the industry and through the supply chain is maximised.

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