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GL Garrad Hassan

Analysis on the furthering of competition in relation to the establishment of large offshore wind farms in Denmark.

Background report 2: Analysis of competitive conditions within the offshore wind sector

Ministry of Climate and Energy

April 28th 2011

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Contact details

- Carsten Jørgensen, Partner, Tel: +45 36 10 26 14
- Martin Enevoldsen, Senior Manager, Tel. +45 36 10 21 74

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1. Introduction

This report is part of the analysis of competition in relation to the establishment of offshore wind farms in Denmark. The report presents the results of the analysis of competitive conditions within the offshore wind sector. The overall objective is to predict expected underlying cost trends and industry appetite for future offshore wind sites. Hence this report is intended to provide an analysis of competitive conditions within two specific areas of the offshore wind farm industry:

1. An analysis of the historical, present and future level of competition within the offshore wind supply chain, delivering a projection of capital cost trends for the next decade (as reported in Section 2); and,

2. An analysis of competitive pressure between national markets for offshore wind, delivering a projection of residual appetite from project developers for site allocation awards for the next decade (as reported in Section 3).

The report is based on strategic advice from GL Garrad Hassan (GLGH) and has been developed in cooperation with Deloitte. The report is based on a number of GLGH's databases and market studies, Deloittes' and GLGH's network of experts and insight into the offshore wind industry.

The report is summarized in chapter 4 of the main report.

2. Competition within the offshore wind supply chain

The focus of the following analysis has been to project anticipated future trends in the cost of delivering offshore wind capacity with reference to supply chain dynamics as well as other important cost drivers. Throughout, the focus of the work has been establishing drivers and trends affecting capital costs (CapEx) given the capital-intensive nature of the power generation technology in question. For the purposes of the current work, future trends in operational expenditure (OpEx) as well as energy production have been neglected and therefore are considered as neutral variables.

2.1 Historical Context

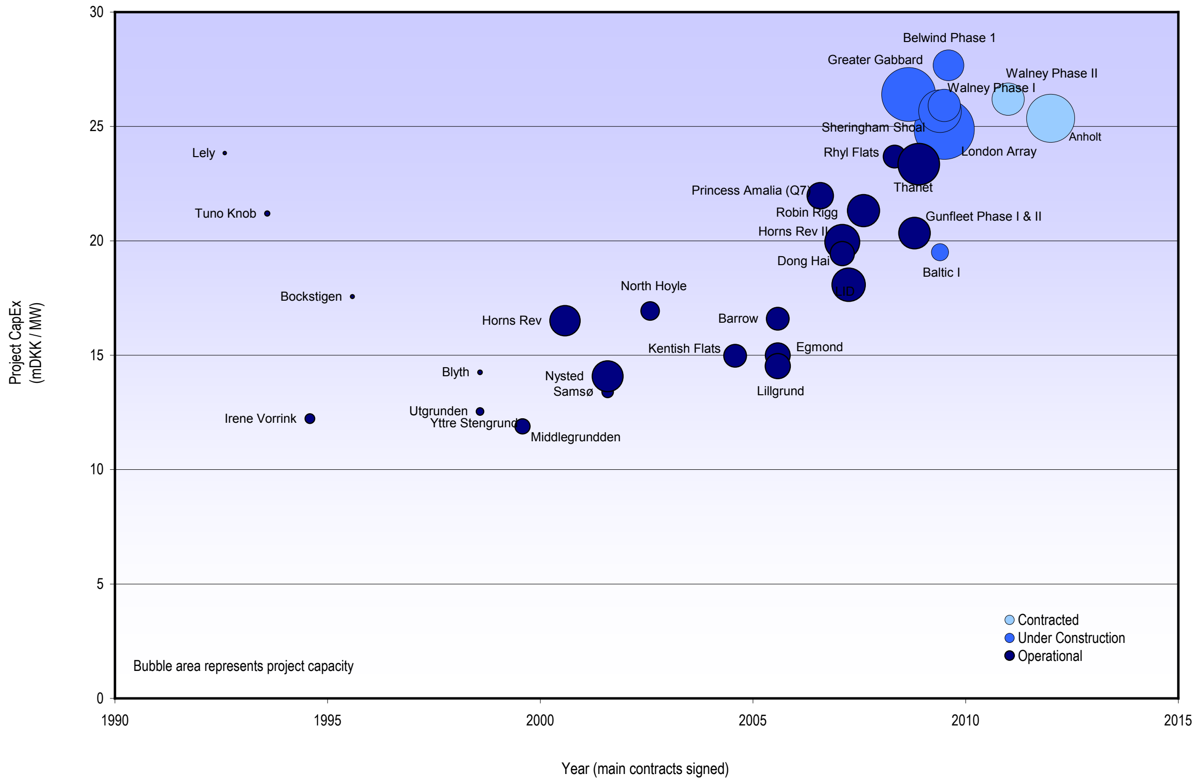
A historical review of the supply-demand imbalances which have plagued the offshore wind industry to date is presented in this section. As part of this review, the role of shifting contracting structures and the impact of these developments on competition and pricing has been considered. Where issues are identified that have had historical relevance to the success or otherwise of a national market, and specifically the Tender Model of that market - specific findings have been drawn.

GLGH has recorded all major public domain contract award announcements within the offshore wind industry during the pre- and early commercial phases of this sector. The broad trend since the early days of offshore wind technology in the early 1990s is contrary to any expectation of conventional industrial maturation. Learning or experience curve theory would predict reducing costs with time, through the combined impact of innovation, learning effects and economies of scale. The historical reality has been dramatically different as illustrated below in Figure 2.1, with a CapEx increasing by approximately 100% in real terms, in the 4 year period from 2005 to 2008.

Figure 2.1 presents CapEx for the majority of offshore wind projects contracted since 1990. The values utilised for the chart are based on published information - typically contractor or developer press releases and / or guidance from the relevant project owner through direct consultation. The values have been adjusted for currency, inflation and scope differences. Currency adjustments (principally between sterling, euro and Danish krone) have been made using historical inter-bank data from oanda.com, referenced from the approximate date of financial close or signing of major construction contracts. Inflation adjustments before 1998 have been based on UK Retail Price Index (excluding all housing) using data obtained from the Office for National Statistics. For 1998 onwards, the average of RPI and euro area inflation (Harmonized Indices of Consumer Prices) has been taken - the latter being obtained through the European Commission Eurostat portal. Adjustment for scope differences has been made in cases where grid connection including offshore substation have been provided by a third-party. In these instances, an increase of 15-25% has been added which based on GLGH experience is a realistic reflection of the cost of such works. In addition, reductions have been made in cases where Warranty, Operational and Maintenance costs have been included in the published value at a rate of €150k per wind turbine per annum which, again, is based on GLGH experience and is broadly representative of current and historical levels.

In the case of the Anholt project, the only publically available data suggests a total project cost of 10Bn DKK[1], as an estimate from the project owner Dong Energy. It has been assumed that this total includes the cost of grid connection infrastructure (borne by the network operator).

Figure 2.1. Historical trends in offshore wind capital cost



Projects contracted before 2000 were typically supported through national or EC capital subsidy and had a strong R&D focus with significant academic involvement. To that extent, these early deployments - whilst of substantial technical value, have been disregarded for the purposes of the current study which is concerned with cost-trends for commercial projects.

The most important drivers or events which have influenced the CapEx trend since 2000 are discussed below.

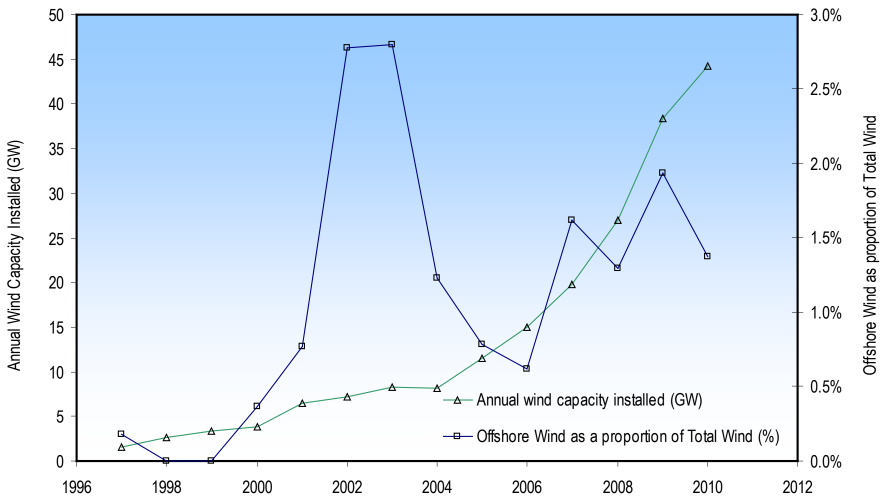
1. **High early competition and losses (2000 - 2004)**
   The initial high degree of optimism over the long-term prospects for offshore wind led to fierce competition between contractors for the early demonstration projects. In an attempt to establish a good market position, optimistically low EPCI (Engineer, Procure, Construct, Install) contract prices were offered. Be it due to a deliberate policy of 'loss-leading' or inadvertent cost optimism, it is considered unlikely that the principal contractors turned a profit on these early engagements. Evidence for this is demonstrated through the subsequent insolvency or buy-outs of several key second tier contractors - notable examples including Dutch Sea

[1] Bloomberg Article "Siemens Wins 111 Offshore Wind-Turbine Order in Denmark From Dong Energy" 22 June 2010.

Cable[2], CNS Renewables[3] and Mayflower Energy[4]. This early negative experience led to the withdrawal of EPCI contract offerings by the leading wind turbine suppliers for future projects in 2004, as the full extent of the offshore construction risks were recognised as being outside of core competencies. Despite the passing of certain key risks to project owners that the transition to multi-contracting landscape has instigated, subsequent market readjustment has actually put upward pressure on prices, as contractors attempt to ensure that the earlier losses are not repeated.

2. **The onshore wind boom (2005 - 2008)**
The rapid acceleration of onshore wind energy deployment, fuelled by particularly strong growth in North America and Asia as well as sustained expansion in Europe, has placed significant upward pressure on wind turbine prices as demand outstrips supply. Turbine production capacity has, to a large degree, been limited by second and third tier supplier constraints. In particular shortages of key components such as gears, large bearings, transformers, castings, forgings and carbon-fibre have contributed to this trend. Currently, the market for offshore wind turbines is largely coincident with that for onshore projects both in terms of players, products and production facilities.

Figure 2.2. Offshore wind - historically a niche market



Sources: WWEA, GLGH

Given the additional risks associated with supplying technology to the offshore market and the high demand for turbines in low-risk onshore markets, manufacturers have until recently had limited incentive to bid competitively for supply contracts to offshore wind projects. Indeed there is only limited incentive to invest heavily in ramping up dedicated production facilities for what is considered by some as a high-risk marginal market. The plot in Figure 2.2 above, illustrates the point, showing offshore wind peaking in 2003 with a share of the total wind market of 2.8%, by annual capacity added. By 2010, this has reduced to just 1.4%, largely as a result of

[2] Press Release, announcing formation of Dutch Sea Cable-Oceanteam BV, 20 February 2004.

[3] "Cns Subsea calls in the administrators" reNews 20 May 2005.

[4] "Mayflower installation ship sold for just £12m" Daily Telegraph 22 April 2004.

spectacular growth in onshore wind in Asian markets and in spite of a significant slowdown in North American markets.

3. **Turbine suppliers EBIT shift (2006 - 2008)**
Super-imposed on the worsening supply-demand imbalance has been a general trend towards greater profitability for the established European-based wind turbine manufacturers. Historically, corporate pricing strategies have focused on expanding (and in reality, defending) market share. As the wind business has matured, the transition towards greater margins is perhaps inevitable, especially in light of the historically low levels of return experienced.

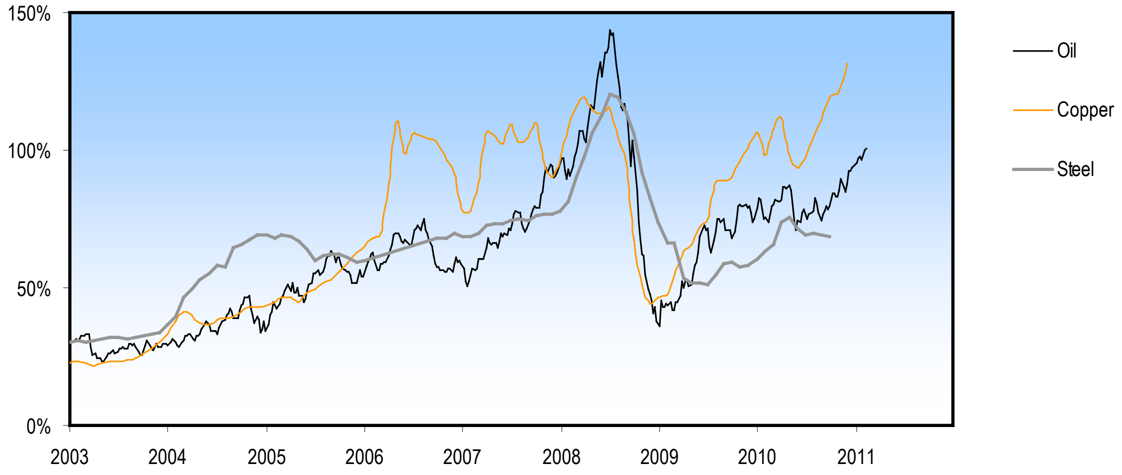
4. **Reducing turbine supplier participation (2004 - 2008)**
Three key industry events have reduced competitive pressure within the offshore wind turbine supply market. Firstly, the merger of NEG Micon with Vestas in late 2003 which ultimately eliminated the offshore-specific product line of the former, given the obvious overlap with Vestas' own product development programme. Secondly, the absence of GE Wind Energy from the turbine supply market since 2004 has removed the world's second largest supplier of wind turbines from the game. It is noted that GE have now re-entered the offshore wind market. In 2007, the temporary withdrawal from the market of Vestas' principal offering for offshore projects (the V90-3.0MW model) due to technical difficulties relating to the gearbox5, reduced supply competition to an all-time low in the period from mid-2007 to mid-2008. The industry was effectively reduced to a single supplier for commercial scale projects wishing to contract during this period (Siemens Wind Power).

5. **Vessels and Balance of Plant Crunch (2007 - 2010)**
In the period 2007 - 2010 the scarce availability of suitable main installation vessels for the deployment of foundations and erection of wind turbines, has caused significant upward pressure on day rates. Competition for supply chain resource from the oil and gas (O&G) sectors was initially a factor here. As important has been the changing nature of project demands, with increasing water depths and lift capacities - narrowing the field of plant suitable for each project. In addition, key electrical plant, most notably transformers and high voltage subsea cables, have been in short supply. This has primarily impacted on lead times rather than pricing, although inevitably some upward price pressure has fed through from this part of the supply chain.

6. **Raw materials and currency (2008 - 2009)**
Shifts in key commodities markets feed through the supply chain and following some lag will have an impact on CapEx for those elements of the project where the value-content of raw material is substantial. For offshore wind, persistent increases in steel prices since early 2007 through to a sharp peak in mid-2008 has impacted on foundation and wind turbine costs. Changes in copper markets impact the cost of electrical plant including wind turbine subcomponents, but overall it is a substantially less important commodity for offshore wind projects. More recently, the precipitous decline of sterling against the euro since mid-2008 has had a substantial and immediate impact on prices for UK projects approaching agreement on major construction contracts during this period, with typically ~80% of the project value charged in euro (or Danish krone - the value of which is pegged to the euro). Clearly currency risk is substantially reduced for Euro Zone projects.

[5] Vestas Wind Systems A/S Company Announcement No. 11 / 2008 "V90-3.0MW offshore wind turbine back on the market again".

Figure 2.3. Fluctuations in key commodities



Sources: MEPs , LME and EIA, World Bank

7. **Increased incentives**
   Arguably, CapEx has also responded to increases in off-take values most notably in the UK market through the 2007 and 2009 announcements of enhanced ROC levels for UK offshore projects. In addition, successive increases in the Feed-in Tariff available to offshore wind projects in Germany may have also affected commercial pricing for early projects in this market. This feedback mechanism has been assumed manifest through Points 3 and 5 above but also has significant implications for the competition between national markets for developer and supply chain attention.

In summary, the historical imbalances and dynamics associated with the offshore wind supply chain have driven the economics of project delivery to date. They have obscured and dominated learning curve effects, leading to a steep escalation in the CapEx, which in turn have resulted in demands from developers for increased subsidies in order to meet hurdle IRR levels for individual projects. Those national markets best able to respond to such demands quickly have attracted the greatest level of developer and supply chain activity. In the way, it may be argued that the perception of attractive levels of subsidy support for offshore wind in the UK has had a significant influence on;

- the level of competition between project developers for site allocations in alternative national markets - directly influencing Tender pricing in the case of DK and NL; and,
- the availability of supply chain capacity to projects in alternative national markets, with the limited existing capacity targeting those markets where the great margins can be leveraged via project developers.

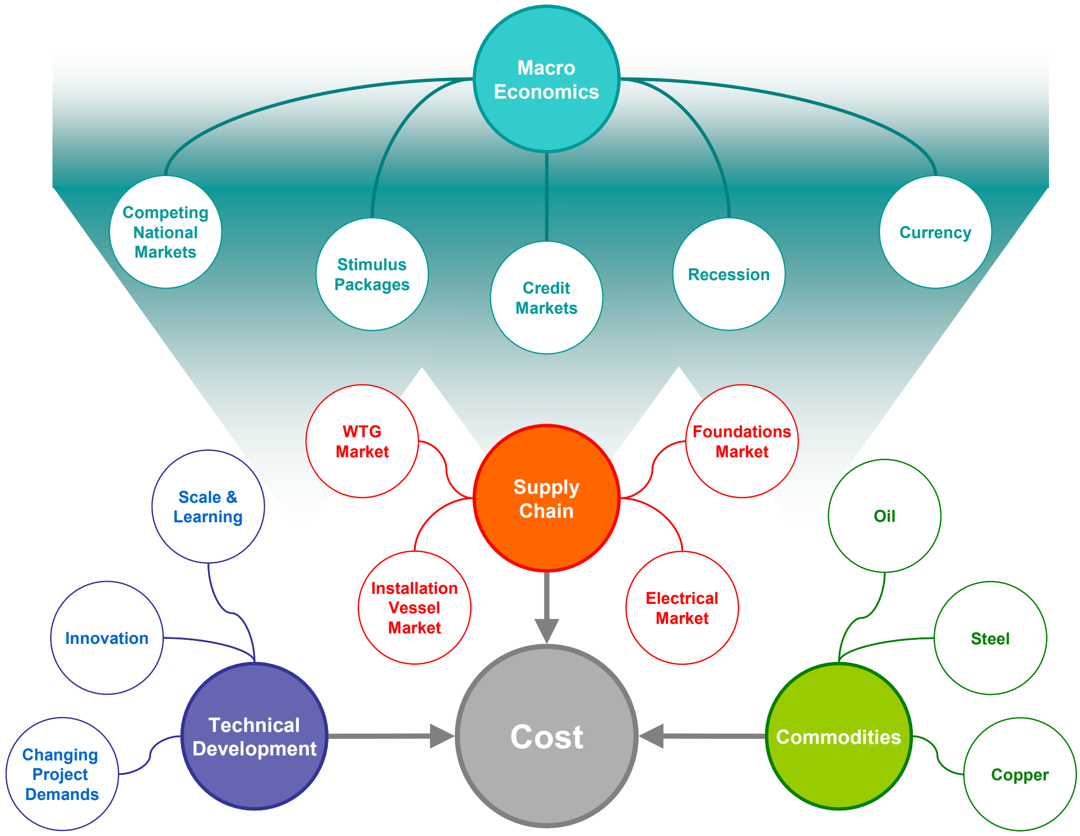
2.2 Current Trends and Drivers

Current trends with respect to the cost of project delivery have been assessed via an analysis of the underlying Drivers associated with such costs. Analyses have been implemented on the basis of historical industry evidence as presented in the previous section as well as consultation with GLGH staff actively engaged in the procurement processes of offshore wind projects currently. This has allowed the relative importance of the identified Drivers to be established and to define the most crucial inter-dependencies that exist between them. This has been implemented in order to inform the development of credible future cost scenarios which are presented in Section 2.3. In this way the study has been implemented as a two phase process - dissection of the problem into constituent *Drivers* before reassembly into credible future *Scenarios*. At this stage, some working definitions are identified:

Driver	*Any factor affecting the capital cost of a offshore wind project.*
Scenario	*A future projection of CapEx based on changes to one or more Drivers.*

Figure 2.4 below depicts, a 'mind-map' of what are considered to be the most significant Drivers both historically and moving forward. It is noted that consideration of Drivers associated with project revenue or operational costs for offshore wind are outside of the scope of the current study.

Figure 2.4: Cost Drivers



As can be seen above, Drivers having a direct impact on costs have been identified in each of three major categories; Supply Chain, Commodities and Technical Development. The inter-dependencies between the identified Drivers are not shown in Figure 2.4 but play a key role when considering the outlook for offshore wind costs. Macro Economic effects influence most if not all of these Drivers to a varying extent. The most important inter-dependencies are catalogued and discussed in this section before application in the 10 year Scenario projections described in Section 2.3.

A 'base case' project value profile has been derived on the basis of GLGH commercial and technical experience in the industry - assumed to broadly represent the cost structure of a typical offshore wind project under construction in 2011. The following basic characteristics can be assumed for the base case project value profile:

- Installed capacity 200 - 600 MW
- Water depths 15 - 25 m
- Foundation concept Monopile
- Wind turbine technology 3-4 MW, conventional design
- Distance from coast 15 - 25 km

The base case project value profile is presented in Table 2.1 below.

Table 2.1. Assumed base case project value profile

Contract/Category	Total Share	Value Content		
		Install.	Steel	Copper
Wind Turbine Supply & Install	**50%**	10%	10%	2%
Foundation Supply & Install	**25%**	30%	25%	0%
Electrical Supply & Install	**15%**	40%	5%	10%
Project Management	**5%**	0%	0%	0%
Miscellaneous	**5%**	0%	0%	0%
Total (value-weighted)	**100%**	19%	12%	3%

Whilst project-specific factors will inevitably mean that the profile above will not fully reflect individual cases, the broad contractual and value-content breakdown assumed is considered to be a reasonably representative, simplified base case.

In order to assess the relative importance of each Driver, a characterisation of 'sensitivity' has been formulated. This captures the combined impact of both the value-content at risk to changes in the Driver and the inherent likelihood of a systematic shift in that Driver over a 10 year period - in other words, volatility.

The **Value-at-Risk (VaR)** for each of the Drivers has been estimated through the definition of a high level value content breakdown for a typical offshore project (as outlined in Table 2.1 above). This is defined as the proportion of the total capital value of the project which is subject to fluctuations to a particular cost driver. For example, Table 2.1 shows that 12% of the project value is subject to variations in steel markets hence the VaR for this driver is 12%.

The inherent **Volatility** for each Driver has been characterised through the definition of 10-year high and low cases based on historical evidence, industry consultation and 3rd party published outlooks. This represents the variation in the pricing level of the cost driver itself that can reasonably be expected over the timeframe of interest. For example, the volatility of the market for rolled plate steel is estimated as +/-30% over a 10 year future timeframe on the basis of published estimates and historical evidence, as described further in Section 2.2.5. Ultimately, this is a subjective measure of future possible trends in each of the identified Drivers. Nonetheless, it is considered to be a reasonable means of framing potential future variations within a credible envelope when attempting to project future cost trends.

By taking the product of the defined **VaR** and **Volatility** ranges, a **Sensitivity** range may be defined for each of the identified Drivers. In the example case of steel, this yields an overall sensitivity range of +4%/-4% of total project CapEx (12% VaR × +/-30% Volatility). Effectively, this Sensitivity parameter represents how *important* each of the Drivers are in determining future capital costs for offshore wind.

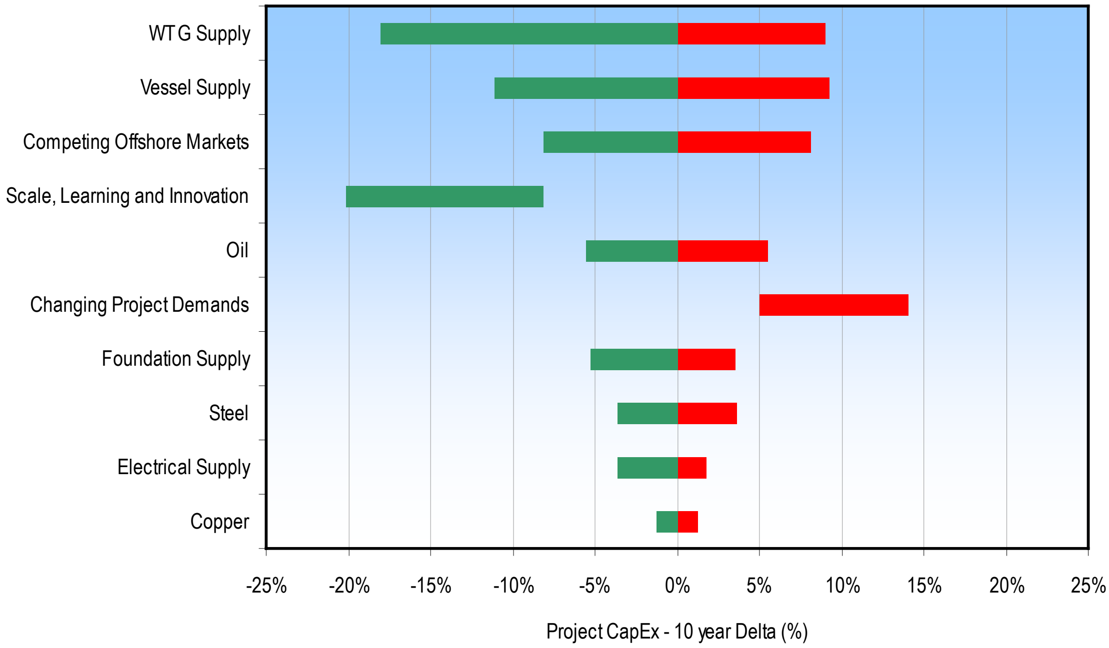
The magnitude of VaR, Volatility and the resultant Sensitivity have been categorised into four broad levels of total project CapEx to aid the assessment of each Driver, as outlined below in Table 2.2.

Table 2.2. Driver sensitivity framework

Magnitude	VaR	Volatility	Sensitivity
Low	< 10%	< 10%	< 5%
Moderate	10 - 40%	10 - 25%	5 - 12.5%
High	40 - 60%	25 - 50%	12.5 - 20%
Very High	> 60%	> 50%	> 20%

The overall results of the sensitivity analysis are presented in Figure 2.5, which ranks the identified Drivers in approximate order of importance from most to least. The x-axis represents the Sensitivity which may also be considered as the potential change in (Delta) average offshore wind project CapEx over the next decade, as referenced to a nominal base date of 2010. As described further in Section 2.3.4, overall average project CapEx for this base date is assumed to be 26 mDKK / MW, on the basis of published contract values for this period.

Figure 2.5. Driver Sensitivity Analysis



Certain Drivers are considered to have asymmetric sensitivity profiles and this is reflected in the analysis. The overall range between the high and low cases is considered to be of most importance.

There follows a discussion of each Driver in which background evidence is presented for these sensitivity results.

2.2.1 Wind Turbine Supply Market

Description and current trends

For several years, demand for wind turbines has significantly outstripped supply causing consistent upward pressure on commercial prices for the wind energy industry generally. In addition, there has been a general drive towards increased profitability for the wind turbine suppliers who have historically suffered low margins.

It is considered likely that the latter of these two factors has already been largely accounted for in turbine pricing shifts in the period 2007-2009. In addition there are some indications that supply-demand imbalance of recent years is in the short-term (next 3 years) beginning to ease, with increased levels of competition between the few existing incumbent suppliers. In the medium-term, the prospects of further improvements in the level of competition increases with new entrant suppliers from both Europe and notably Asia, providing additional supply capacity - as examined further in Section 2.3.

There is now clear evidence of a trend towards offshore specific wind turbine products and in some instances, suppliers. This trend should mitigate the historical 'resource diversion' suffered by the offshore wind industry, particularly as suppliers commit to significant investment in bespoke production facilities. There is strong evidence for this with all three suppliers with near-market products in the 5-6 MW range commissioning substantial production facilities in the last few years. Whilst production is yet to ramp-up to serial levels at these sites (all in northern Germany), the development signals that this critical part of the supply chain now has the confidence in long-term sustainable markets.

However, the bifurcation discussed above, which is considered to be an important current trend, will not entirely mitigate the broader impacts of continued high levels of demand from the global onshore wind business, since 2nd and 3rd tier sub-suppliers are likely to remain largely common to both onshore and offshore products and players. Recent announcements have indicated a scaling-back of new production capacity from previous plans for certain key sub-suppliers which on the surface would suggest a further tightening of supply. In reality it is considered that this development is in anticipation of cooling demand from onshore wind and in this respect may not impact the offshore market directly.

Driver Sensitivity

- Value at Risk (VaR) High [45%]
- Volatility Very High [+20% / -40%]
- **Overall Sensitivity** Very High [+9% / -18%]

2.2.2 Foundation Supply Market

Description and current trends

To date foundations for offshore wind projects have been dominated by monopile solutions. Whilst there are currently only 3 established suppliers of monopiles of the diameter required, active in the offshore wind market, the general industry consensus is the levels of capacity dedicated to offshore wind is currently of the order 1 GW with reasonable potential for expansion or redeployment of production resource at existing facilities.

As projects located in deeper water (beyond 20-25m) approach deployment, monopiles start to become less economically attractive, especially when larger wind turbines are under consideration. Multi-member structures (such as jackets and tri-pods) become important here and in some instances concrete based structures are under consideration. For these alternative concepts, the supply chain is at an early stage although there is evidence to suggest that contractors with substantial capacity and experience from other industries are targeting the offshore wind market as demand ramps-up.

For offshore projects to be contracted within the 10-year timeframe of the current study, it is considered likely that monopiles will continue to dominate but with increasing penetration from jacket structures likely for projects contracted after 2015. In both instances the cost base of supply is massively exposed to the vagaries of commodity and potentially currency markets.

The overall sensitivity of the foundation supply market as a cost Driver is considered to be moderate - which reflects the historical and anticipated future levels of reasonable competition and production capacity in this area.

Driver Sensitivity

–	Value at Risk (VaR)	Moderate	[18%]
–	Volatility	High	[+20% / -30%]
–	**Overall Sensitivity**	Moderate	[+4% / -5%]

2.2.3 Electrical Equipment Supply Market

Description and current trends

Transformers and subsea cables are the principal electrical items that have been in short supply for the offshore wind industry in the recent past and this trend is anticipated to continue in the near-term. For these elements and the other electrical components required for collection, transmission and grid connection, the offshore industry is drawing on a much larger supply base, principally serving the utilities and network operators.

Whilst the limited supply of these components has significantly extended lead times, historical shifts in pricing have been less dramatic which is largely the result of a mature and broader supply chain being in place. Future deployment plans for offshore wind will make this sector the dominant market for subsea high voltage cable which will alter this situation.

Driver Sensitivity

–	Value at Risk (VaR)	Low	[9%]
–	Volatility	High	[+20% / -40%]
–	**Overall Sensitivity**	Moderate	[+2% / -4%]

2.2.4 Installation Vessel Market

Description and current trends

A number of different classes of vessel are required to construct an offshore wind project but the majority of the costs are associated with the lease of the main installation vessel for foundation deployment and turbine erection. Historically, the market for suitable vessels for such operations has been highly volatile for a number of reasons relating to the supply-demand balance.

Prior to 2003, early offshore wind deployments were reliant on vessels from other industries with varying degrees of conversion and refitting required. In the period 2003-2005, the first two main installation vessels purpose built for the offshore wind market ("Resolution" and "Jumping Jack" - later renamed, "Sea Jack") came into full operation just at a time when project demand was waning. This ultimately led to financial difficulties for the vessel owners during the lean period and to the sale of the major assets and associated equipment, in both cases (twice in one instance). The surge in project demand from 2007 onwards has led to substantial upward pressure on day-rates for these and other suitable options which have been converted for use in the wind industry since. This is evidenced by the use of expensive floating shearleg vessels for monopile installation operations for some projects in the absence of suitable, less expensive alternatives.

This trend has continued for the last year culminating in a 'vessel crunch' for projects deploying in the 2009, 2010 and 2011 build seasons. It is estimated that in 2009 there were 5-6 main installation vessels specifically targeted for use in the offshore wind sector be they new-builds or conversions, but that the degree of construction activity planned demands up to 8 such vessel when factoring in demand from the repair market. The additional capacity is being found (albeit at a price-premium) from other industries - principally O&G and coastal engineering, which is only possible due to the current lull in construction activity in these sectors.

Whilst there are many bespoke vessels targeting the offshore wind sector on the drawing board, investment decisions on risky ventures such as offshore construction plant are likely to be delayed in the current financial climate. On the other hand, recently the supply chain has demonstrated a greater degree of responsiveness as confidence increases that a viable long-term business is up for grabs. Currently, 13 additional main installation vessels are under construction or on order and whilst there is significant potential for cancellation or at least delay, the current trend proves that contractor appetite is reasonably strong.

The influence of the offshore O&G sector upon vessel availability and costs is dealt with as a separate Driver (Section 2.2.7) being strongly linked to trends in global oil prices.

Driver Sensitivity

–	Value at Risk (VaR)	Moderate	[19%]
–	Volatility	Very High	[+50% / -60%]
–	**Overall Sensitivity**	Very High	[+9% / -11%]

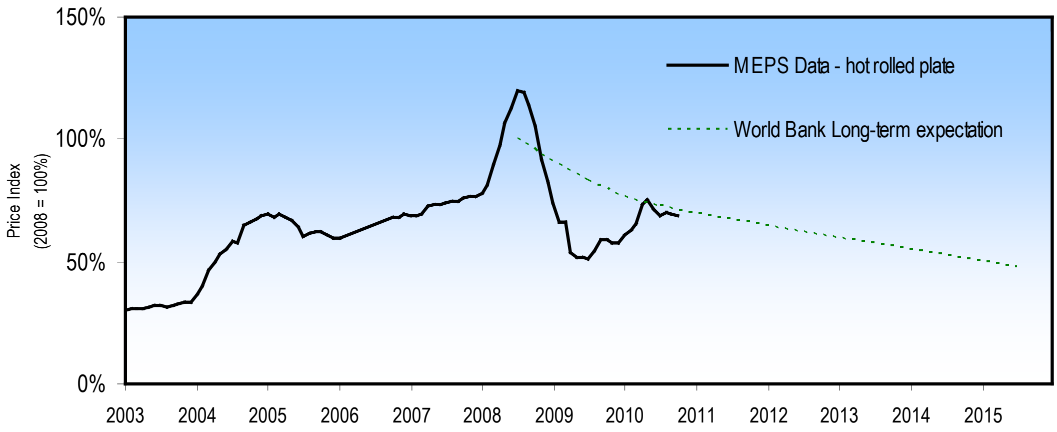
2.2.5 Steel

Description and current trends

Much has been made of the impact of soaring steel prices throughout 2008 on the overall cost of offshore wind projects. Whilst the value of steel is certainly the most influential commodity when considered as raw material content of the project and this value content is certainly subject to global market shifts, its overall importance has often been misrepresented.

As presented above, the overall value-content for a typical offshore wind project which is subject to variations in wholesale steel prices is estimated to be approximately 12%. The volatility of global spot markets for steel is in general subject to some degree of lagging when considering the plate material required for fabrication of wind turbine towers and foundations, since materials are purchased by the supply chain well in advance of fabrication and assembly. In addition to the 'delayed reaction' effect, such lagging is generally also anticipated to smooth-out the greatest fluctuations of the commodity market. Figure 2.6 presents historical and project future trends for steel.

Figure 2.6. Expected long-term trend in steel pricing



The World Bank projection above reflects the overall long-term expectation to 2015 with the general downward trend largely a reflection of the substantial reduction in demand throughout the global recession. A positive economic recovery scenario would suggest stabilisation or indeed reversal of this trend as global demand reboots, especially as a result of significant spending on infrastructure through stimulus measures in 2009/2010.

Added to these global considerations are sector-specific factors and in particular issues relating to the steel grade required by industry standards for deployment of foundations which has limited the number of potential second- or third-tier suppliers of plate material, thus reducing competition. As with several other Drivers examined in this study, without improved levels of competition within the offshore wind supply chain, the potential benefit of current and future reductions in the wholesale price of steel is unlikely to feed through to project CapEx.

Driver Sensitivity

–	Value at Risk (VaR)	Moderate	[12%]
–	Volatility	Very High	[+30% / -30%]
–	**Overall Sensitivity**	Moderate	[+4% / -4%]

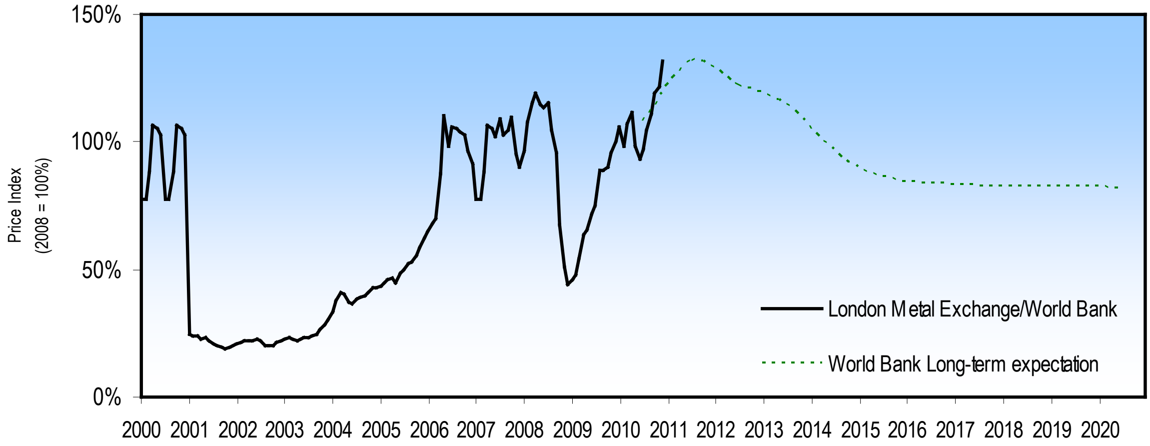
2.2.6 Copper

Description and current trends

Also considered by some to have significant impact on the cost of offshore wind projects is copper as a commodity. Copper is present in considerable quantities in electrical cables and other components such as transformers. However, the raw material value-content of such components is surprisingly small, with the majority of costs incurred during the manufacturing process.

As illustrated in Figure 2.7, historical data demonstrates this high degree of volatility inherent in the copper market. As with steel, the World Bank expectation to 2020 is for a gradual downward decline, stabilising from 2015.

Figure 2.7. Expected long-term trend in copper pricing



As demonstrated by the calculation of driver sensitivity for the current study, fluctuations in the copper market can be characterised as something of a 'red herring' in the context of offshore wind CapEx.

Driver Sensitivity

–	Value at Risk (VaR)	Low	[3%]
–	Volatility	Very High	[+50% / -50%]
–	**Overall Sensitivity**	Low	[+1.3% / 1.3%]

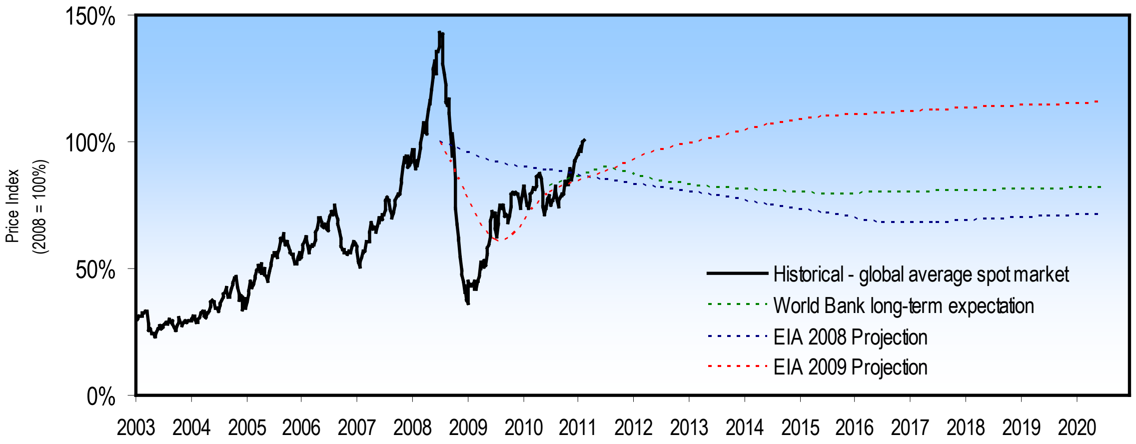
2.2.7 Oil (secondary impact thereof)

Description and current trends

Oil has been considered in the current study to the extent that its market price affects the level of offshore marine exploration and construction activity, which has the potential to divert scarce vessel resources away from offshore wind. The flip side being the potential for the widening of the vessel supply market for offshore wind in a low oil price scenario - increasing competition and driving down costs.

Figure 2.8 presents historical spot market data for oil normalised to the average for 2008 along side World Bank and Energy Information Administration (EIA) projections to 2020.

Figure 2.8. Diverging opinions on crude



Since peaking in July 2008 at just under $150 / barrel, oil prices collapsed, with the beginnings of a recovery towards historical levels evident in Q2 2009 and following this a persistent upward trend towards $100 / barrel. The World Bank and 2008 EIA projections show reasonable overall agreement - predicting the market to converge towards ~$70 / barrel. In contrast the later EIA projection implies a strong sustained recovery in oil prices beginning in the middle of 2009 and trend towards ~$100 / barrel at 2015.

It is difficult to make credible quantitative predictions of the secondary impact of such projections on the level of competition in the vessel supply market for offshore wind construction activity. Essentially, the future price of oil is likely to bias vessel prices according to the degree of resource divergence / inflow from the partially competing offshore O&G sector.

It could be reasonably postulated that in a high oil price scenario such as the EIA 2009 projection, that the supply of new vessels specifically targeted at the offshore wind sector remains low and furthermore, that further conversion / utilisation of vessels from O&G into offshore wind do not materialise. On the other hand, under the depressed price projections for oil to 2020, it is reasonable to assume that as a minimum, existing and planned vessel capacity for offshore wind, remains by and large reserved for the industry intended use. With a slightly more optimistic outlook, it may be possible that low future oil prices would lead to some conversion or additional 'entrainment' of existing O&G vessels for offshore wind construction jobs. We are currently seeing an increasing trend in this regard as O&G activity is currently in a low period. Whilst such plant may in many cases be over-specified for the tasks required, the elasticity of pricing in the marine contracting sector should ensure that the increased levels of competition implied will drive down day rates and hence CapEx. Clearly the price of oil also has a more direct impact because of the relatively intense use of fuels in the manufacture, fabrication and installation activities, but for the purposes of the current study, considering oil as a driver in this sense has been neglected because of its lesser overall importance.

It is noted that increased oil prices may also affect offtake values due to the correlation with the wholesale electricity price. This will depend on the nature of project offtake arrangements and the complex dynamics between oil and electricity markets. This factor has been neglected in the analysis presented here.

Driver Sensitivity

–	Value at Risk (VaR)	Moderate	[19%]
–	Volatility	Very High	[+30% / -30%]
–	**Overall Sensitivity**	Moderate	[+6% / -6%]

2.2.8 Changing Project Characteristics

Description and current trends

CapEx clearly affected by the changing nature of project sites. There are three historical and ongoing trends in this regard:

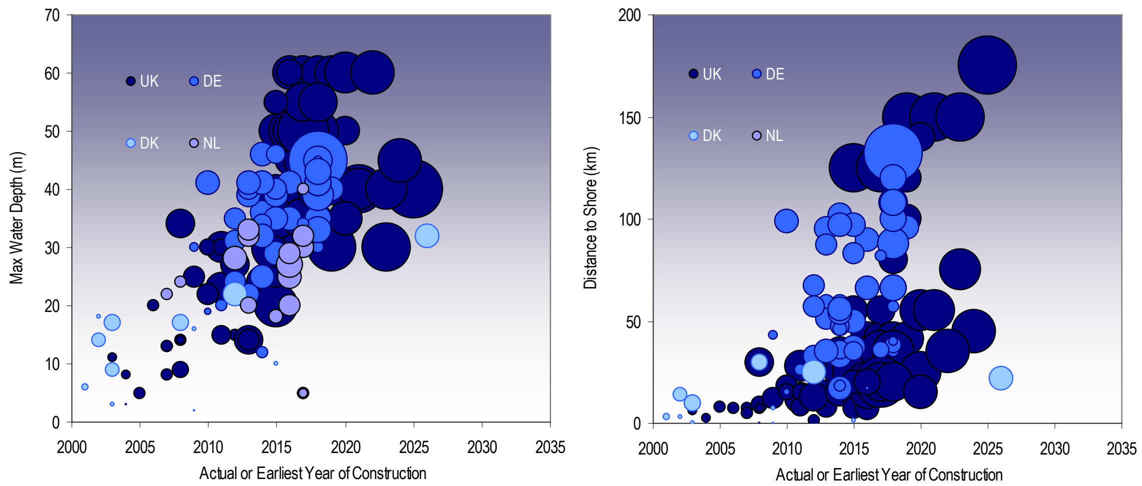
1. Deeper water leading to a switch in foundation concept, consequent increase in turbine capacity and additional installation demands;

2. Sites further from shore leading primarily to additional electrical system requirements; and,

3. Larger projects leading to longer build durations and additional infrastructure demands.

Figure 2.9 presents these historical and anticipated future trends for projects where exclusive site development rights (concession) has been awarded or applied for, within the primary markets considered in the current study.

Figure 2.9. Into the blue - deeper and further



Bubble area represents project capacity

The following table compares project averages for the periods 2005-2009, 2010-2014 and 2015-2019.

Table 2.3. Trends in key technical metrics for offshore wind projects

Period	Max Depth	Delta from (2005-09)	Distance to Shore	Delta from (2005-09)	Installed Capacity	Delta from (2005-09)
2005 - 2009	15.4 m	-	11.5 km	-	118.1 MW	-
2010 - 2014	29.1 m	89%	38.4 km	233%	315.6 MW	167%
2015 - 2019	39.0 m	153%	51.8 km	349%	537.2 MW	355%

It is inescapable that trends in both water depth and distance from shore clearly point towards increasing costs for all major project elements; wind turbines, foundations, electrical plant and installation. This is likely be offset to a limited degree through project-specific scale-effects implied by the average significant ramp-up in average project capacity as the industry moves through the next decade. This Driver is a special case amongst those considered in this study, since in both optimistic and pessimistic scenarios, the impact can only be upward pressure on costs.

Driver Sensitivity

- Value at Risk (VaR) Very High [90%]
- Volatility Moderate [+15% / +5%]
- **Overall Sensitivity** High [+5% / +14%]

2.2.9 Scale, Learning and Innovation

Description and current trends

As any industry matures, all other things being equal, effects of scale, learning and innovation should lead to cost reductions with time. As outlined in Section 2.1, this has clearly not become manifest in the offshore wind sector to date. The potential for future cost saving 'benefits' be they cost reductions or mitigation of cost increases, is assessed below in against the themes of Scale, Learning and Innovation for each of the key technological areas for offshore wind.

Figure 2.10. Anticipated cost reduction potential from scale learning and innovation effects

Technology		Cost Reduction / Mitigation Potential: Scale	Learning	Innovation
WTGs	3 - 5 MW	Low	Moderate	Moderate
WTGs	5 - 10 MW	Moderate	Moderate	Moderate
Foundations	Monopiles	Low	Low	Low
Foundations	Multi-Member	High	High	High
Foundations	GBS	High	High	High
Elec. Design / Supply		Moderate	Moderate	High
Installation	Depth < 15 m	Low	Moderate	Moderate
Installation	15 - 30 m	Low	High	High
Installation	Depth > 30 m	Low	High	High

The most promising areas for cost reduction / mitigation potential are considered to be; design, fabrication and serial production of multi-member foundations, installation operations in moderate to deep waters and innovation in electrical infrastructure technology. These drivers have the potential to mitigate the anticipated cost increases associated with the move towards construction in deeper waters and further from shore. In addition some cost reduction through learning effects is considered to be reasonably likely for wind turbines through a reduction in the 'risk-premium' that has been evident in contract prices since contractor-losses on early projects became manifest. However, this is likely to be offset to some extent by the general trend towards, larger, heavier machines, albeit with some significant elements of innovation (such as direct drive technology) intended to reduce life-cycle costs. A strong 'market-pull' from developers, in the form of substantial framework agreements with key suppliers is considered important in engendering the level of confidence required in the supply chain. In all cases, the benefit of scale, learning and innovation will only be passed through to project costs in a competitive supply chain environment.

Driver Sensitivity

–	Value at Risk (VaR)	Very High	[80%]
–	Volatility	High	[-10% / -25%]
–	**Overall Sensitivity**	High	[-8% / -20%]

2.2.10 Competing National Markets

Description and current trends

Given the well documented supply chain difficulties that the offshore wind industry has faced historically, increased demand from other national markets for the same resource required for any one market will inevitably have an impact on CapEx. Section 3 of this report explores the level of competition for site allocations and the expected trends in this area over the next decade. However, during periods of under-supply, perceived or actual differences in the magnitude of incentive support available to offshore wind projects can lead to the diversion of scarce supply chain resource to the markets where the greatest margins can be obtained.

In recent years, arguably this has been a factor which has affected the German offshore wind sector, whereby supply chain players in certain areas have been seen to target the UK market in preference given the slightly higher levels of revenue incentive available in this market. This factor may become more important over the next decade if supply constraints continue.

Driver Sensitivity

–	Value at Risk (VaR)	Very High	[80%]
–	Volatility	Moderate	[+10% / -10%]
–	**Overall Sensitivity**	High	[+8% / -8%]

2.3 Future Projections

2.3.1 Demand

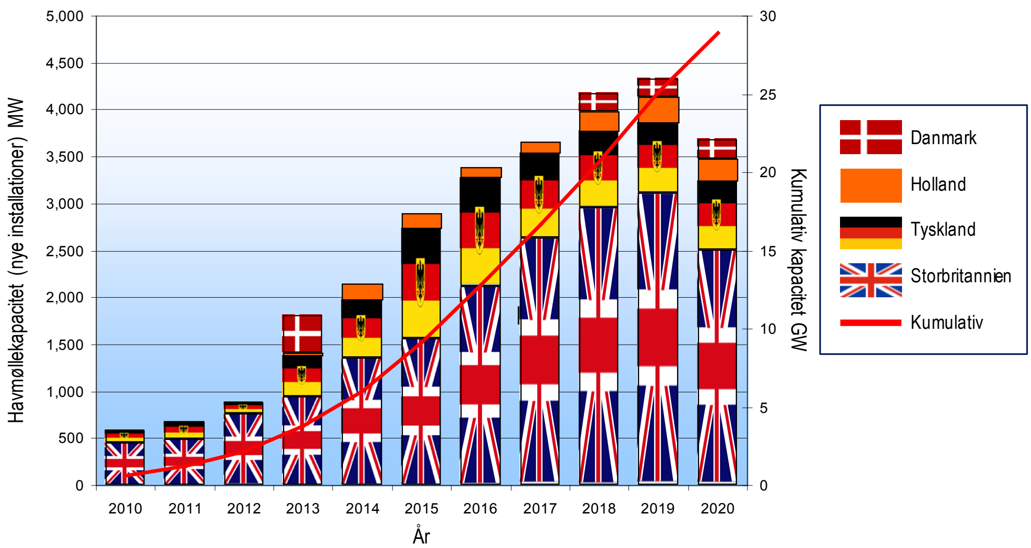
A demand-side projection of installed capacity has been made for each of the Primary Markets based on the GLGH Offshore Wind Farm Projects Database for the period 2010 - 2020. The database and associated methodology is described in more detail in Appendix 1. This projection has been made on the basis of analysis of individual projects including consideration of the probability of delay or cancellation in each case. This analysis has been used to define the expected market demand for the supply chain for the next decade in northern Europe. The results of this analysis are presented below in Table 2.4 and Figure 2.11.

Table 2.4. Projected Demand in the Primary Markets

Year[1]	Demand[2] by Market (MW)				Total Annual Demand (MW)
	UK	DE	DK	NL	
2011	495	175	0	0	**670**
2012	766	114	0	0	**880**
2013	944	436	400	24	**1804**
2014	1353	628	0	163	**2144**
2015	1560	1183	0	147	**2889**
2016	2116	1170	0	105	**3391**
2017	2634	909	0	112	**3655**
2018	2957	810	200	207	**4174**
2019	3116	753	200	263	**4332**
2020	2505	736	200	239	**3680**

1 Refers to year of commissioning / first power production.
2 Delay and cancellation filtering processes results in a smearing effect which results in apparent low levels of capacity in some years for the lesser Danish and Dutch markets. Refer to Appendix 1 for a more detailed description of the adopted methodology.

Figure 2.11. Projected Demand in the Primary Markets



The significant levels of uncertainty with the projection of demand presented in above should of course be noted. Every effort has been made to capture the potential effect of project delays and cancellations although it is impossible to predict the magnitude of these effects with absolute certainty. The market projection presented above is in general somewhat less bullish than alternative estimates in the public domain - most notably those of the European Wind Energy Association and BTM Consult. Even so, there is substantial potential for actual project demand and roll-out to be even less than the projections presented above, particularly in light of shifts in regulation, policy and the broader macroeconomic environment. Nonetheless, the derived demand estimates are considered to be appropriate for use in the current assessment.

2.3.2 Supply

A supply-side analysis has been undertaken based on the GLGH Component and Activity Costing Database and GLGH Offshore Wind Installation Vessel Database, for the period 2010 - 2020. This has been carried out for each of the major Tier 1 disciplines (wind turbine supply, foundation supply, electrical equipment supply and installation vessels) on the basis of current and future planned expansion of capacity.

Projections of supply capacity are notoriously problematic, especially beyond a 2-3 year timeframe. In this regard, the following factors are noted:

- Supply capacity for certain items is relatively elastic and dynamic - ramping up to meet demand within certain tolerances within quite short timeframes. In these cases, pressure on supply from the market is less likely to result in short-term upward pressure on pricing. In majority of cases for the offshore wind sector however, investment decisions for significant additional Teir-1 supply chain capacity must be made 18-36 months in advance of that capacity being available to deliver to projects in execution.

- Plans for additional supply chain capacity that enter into the public domain are often not fully confirmed or do not entail a full investment commitment from the supplier in question. This allows the supply chain to scale back or even cancel plans should perceived future market demand weaken significantly.

- Plans for additional supply chain capacity are largely not in the public domain. This is particularly true for potential new entrant suppliers who may hold back specific plans because they are not fully committed or otherwise confidential for commercial reasons. Again, the perception of future market demand will trigger investment decisions - but these are difficult to predict with any certainty.

For these reasons, dealing with supply and demand independently is to some extent a flawed approach. However, the analysis that follows is intended to provide an indicative qualitative basis upon which general findings may be drawn with respect to competitive pressure within the supply chain and the commensurate effect on project costs.

Wind Turbine Supply

At Tier-1 level, wind turbine supply capacity will be limited by the capacity of the primary assembly facilities of the OEMs. Historical downstream supply chain constraints on key components such as castings and large diameter bearings have largely been resolved via trends towards vertical integration as well as the impact of the broader recessionary environment in parallel industries. On the basis of this assumption, it is possible to define generic capacity profiles, providing an assumed annual production capacity for existing and new WTG products. The following profiles are based on industry experience relating to the programme for the establishment and ultimate capacity of offshore wind turbine assembly facilities. Broadly speaking German and Danish wind turbine manufacturers have adopted the following approach to establishing such facilities:

- An ultimate target market penetration equivalent to 1GW / annum in sales is usually required to justify the significant expenditure (typically €100M or more) associated with product development, supply chain establishment and assembly facilities.

- In general, a single assembly hall and associated support facilities are required with a single shift annual capacity in the order of 500MW, ramping up further to 1GW by moving to 2 shifts.

- Following an investment decision to establish the required assembly / testing facilities, it can take several years to reach operational maturity given consenting, logistical and other constraints. The support of local, regional or national bodies can help to accelerate the time to market.

The above assumptions are supported by the following evidence:

- Siemens Wind Power have an order backlog of ~3GW of capacity of their flagship offshore wind product (SWT-3.6-120) to be delivered to projects in northern Europe in the 2010-2012 timeframe - suggesting full capacity at ~1GW / annum at their assembly facilities in Brande, Denmark.

- Areva (Multibrid) and REpower Systems have both established assembly facilities in Bremerhaven, northern Germany, each with a single shift capacity of ~400MW / annum.

- Direct consultation by GLGH to the leading WTG OEMs during the course of other strategic consultancy engagements has revealed a consistent message with respect to a target annual sales level of ~1GW to justify the launch of a new offshore wind turbine product.

On the basis of the rationale outlined above, the following generic capacity profiles may be assumed:

Table 2.5. Assumed generic WTG capacity profiles

Year[1]	Cautious (MW)	Central (MW)	Aggressive (MW)
0	0[1]	0[1]	0[1, 2]
1	0[2]	0[2]	0[3]
2	0[3]	0[3]	50[4]
3	0	50[4]	200[5]
4	50[4]	150[5]	500[6]
5	100[5]	250	500
6	200	500[6]	1000[7]
7	400	500	1000
8	500[6]	1000[7]	1000
9	500	1000	1000
10	500	1000	1000

1. Investment commitment 2. Plant design / planning etc 3. Plant construction 4. First batch production
5. Series production 6. Full capacity (single shift) 7. Full capacity (two shifts)

The generic capacity profiles presented above in Table 2.5 can be used to extrapolate expect future WTG supply capacity against known WTG suppliers and models as well as anticipated new entrants. With the respect to the latter grouping, there is a significant degree of interest currently from potential new entrants to the offshore wind sector and GLGH is aware of at least 15 credible prospects at the time of writing, including:

- 2B;
- Alstom Wind;
- AMSC;
- Clipper;
- Daewoo;
- Gamesa;
- Mitsubishi;
- Nordex;
- Samsung;
- Sinovel; and,
- XEMC Darwind.

GLGH is aware of other serious potential new entrants, not included on the list above. In general, these entities may be characterised in three groupings; established onshore wind suppliers, industrial majors and start-ups. It is reasonable to assume that many of these companies will not ultimately deploy a wind turbine into to the offshore wind sector - there will be a natural attrition rate as risks are fully understood and corporate policies shift. To account for this, attrition rates of 80%, 60% and 40% have been assumed in the capacity scenarios presented below, leading to 3, 6 and 9 new wind turbine products being assumed to reach some level of market readiness over the next decade.

Table 2.6 on the following page presents the resulting supply capacity projections. Figure 2.12 compares the derived wind turbine supply profiles against the assumed demand profile, as described in Section 2.3.1.

It is clear from the results of the analysis as presented in Figure 2.12 that supply is anticipated to significant outstrip demand for offshore wind turbine products over the next decade, even in the most pessimistic scenario for new entrant products. Oversupply is estimated to range between 2 and 8 GW per annum, which implies that a high and increasing degree of competition within this sector can be expected through to 2020. This is expected to excerpt a persistent downward pressure on margins and pricing for those active in the sector.

Table 2.6. Offshore WTG supply capacity profiles

WTG Model	Annual Supply Capacity (MW)										
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SWP (SWT-3.6-120)	1000	1000	1000	1000	1000	1000	750	500	500	500	500
SWP (6MW)	0	0	0	50	150	250	500	500	1000	1000	1000
REpower (5M/6M)	100	200	400	500	500	500	500	500	1000	1000	1000
Areva (M5000)	0	100	200	500	500	1000	1000	1000	1000	1000	1000
BARD (5.0)	150	200	500	500	500	500	500	500	500	1000	1000
Vestas (V112-3.0MW)	100	200	500	500	1000	1000	1000	1000	1000	1000	1000
Vestas (VY)	0	0	0	50	150	250	500	500	1000	1000	1000
GE 4.1	0	0	50	150	250	500	500	1000	1000	1000	1000
Firm capacity (subtotal)	**1350**	**1700**	**2650**	**3250**	**4050**	**5000**	**5250**	**5500**	**7000**	**7500**	**7500**
New Entrant 1 (cautious)	0	0	0	0	50	100	200	400	500	500	500
New Entrant 2 (central)	0	0	0	50	150	250	500	500	1000	1000	1000
New Entrant 3 (aggressive)	0	0	50	200	500	500	1000	1000	1000	1000	1000
New Entrant 4 (cautious)	0	0	0	0	0	50	100	200	400	500	500
New Entrant 5 (central)	0	0	0	0	50	150	250	500	500	1000	1000
New Entrant 6 (aggressive)	0	0	0	50	200	500	500	1000	1000	1000	1000
New Entrant 7 (cautious)	0	0	0	0	0	0	50	100	200	400	500
New Entrant 8 (central)	0	0	0	0	0	50	150	250	500	500	1000
New Entrant 9 (aggressive)	0	0	0	0	50	200	500	500	1000	1000	1000
Total (80% attrition)[1]	**1350**	**1700**	**2700**	**3500**	**4750**	**5850**	**6950**	**7400**	**9500**	**10000**	**10000**
Total (60% attrition)[2, 4]	**1350**	**1700**	**2700**	**3550**	**5000**	**6550**	**7800**	**9100**	**11400**	**12500**	**12500**
Total (40% attrition)[3, 4]	**1350**	**1700**	**2700**	**3550**	**5050**	**6800**	**8500**	**9950**	**13100**	**14400**	**15000**

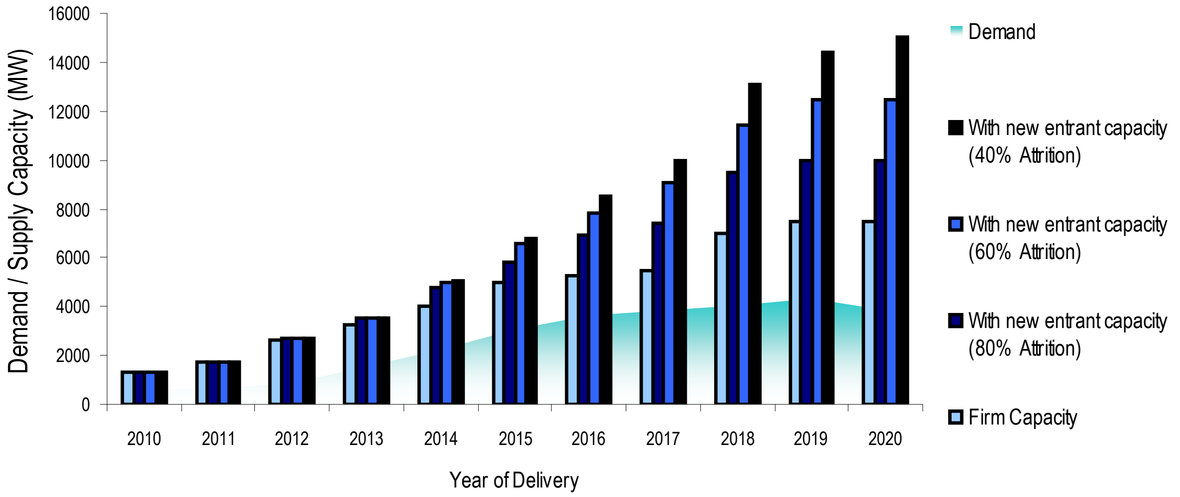
1 Attrition rate of 80% implies only 3 new entrant offshore wind turbine products enter market in period 2010 - 2020.

2 Attrition rate of 60% implies 6 new entrant offshore wind turbine products enter market in period 2010 - 2020.

3 Attrition rate of 40% implies 9 new entrant offshore wind turbine products enter market in period 2010 - 2020.

4 Each additional "wave" of 3 new entrant products assumed to be offset by 1 year in terms of product development and roll-out.

Figure 2.12: Projected offshore WTG demand and supply



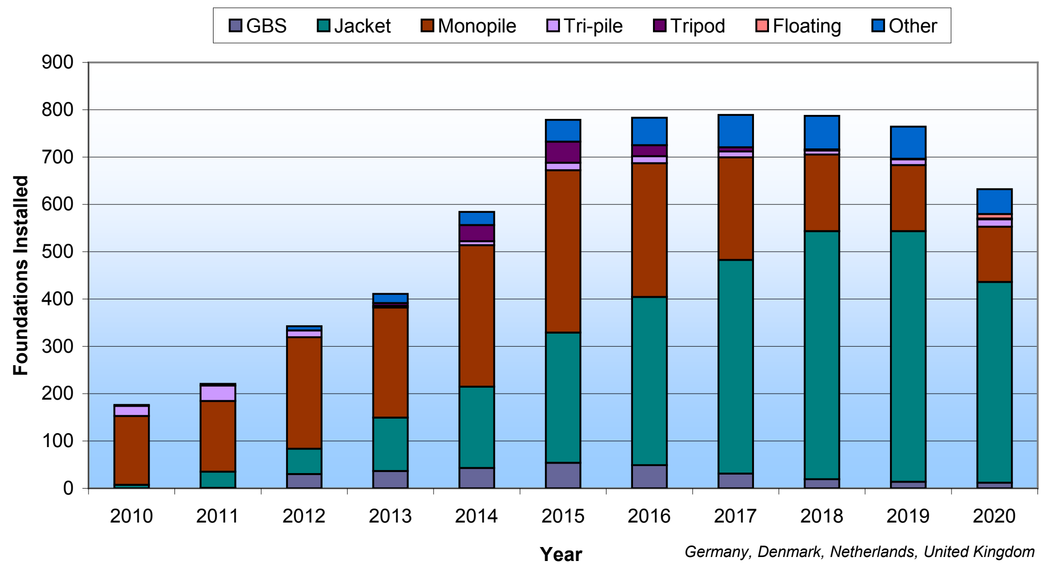
Foundation Supply

Support structures for the wind turbine and offshore substation plant can be characterised in three major subgroups when considering the primary markets in this study, over the next decade.

1. **Monopiles,** fabricated serially via the rolling and welding of plate steel.
2. **Multi-member Structures** (encompassing jackets, tri-pods and tri-piles), fabricated in batches or serially with a significant additional labour content. More economic in deeper waters.
3. **Gravity Base Structures** (GBS), fabricated at bespoke coastal facilities specific to a particular project.

Figure 2.13 below, presents a projection of demand for foundations by type for the next decade.

Figure 2.13. Projected foundation demand by type



As can be seen above, at the time of writing the dominant foundation concepts are expected to be monopiles and jackets. Incumbant suppliers of these foundation types along with announced new entrants are outlined below in Table 2.7.

From the information contained in Table 2.7, it may be surmised that the industry has approximately 4GW / annum of foundation supply capacity available when neglecting GBS technology. This capacity may reasonably be assumed to be relevant in the short-term (2011 - 2013) with additional supply being available either via new entrants and / or expansion of incumbent facilities.

It is important to note that unlike the offshore wind turbine supply market, the barriers to entry for foundation supply to the offshore wind sector are relatively low, due to the inherently lower levels of technological sophistication as well as the relative availability of the required skills and equipment from ship building and heavy industry sectors. The current level of activity within these parallel sectors suggests that supply capacity within the short to medium term will run well ahead of demand, even when taking account of the reduced competition induced by projects which are forced to adopt a particular foundation concept.

Table 2.7. Incumbant, recent and new entrant foundation suppliers

Supplier	Type	Est. Current Capacity (MW / yr)	Comments
SiF	Monopile	1000	Incumbent industry leading supplier
Bladt	Monopiles/JKT	500	Incumbent supplier
EEW	Monopiles	1000	Recent entrant (eastern Europe/Asia)
ZPMC	Monopiles	500	Recent entrant (eastern Europe)
BiFab	JKT	500	Incumbent jacket supplier
Weserwind	Tripod/JKT	500	Incumbent tripod supplier
Aker	Multi-member	Unknown	Recent entrant
Smulders UK	Multi-member	Unknown	New entrant
TAG	Monopiles	Unknown	New entrant
Heerema	Multi-member	Unknown	New entrant
Tata Steel	Monopiles	Unknown	New entrant
Others	Various	Unknown	Potential new entrant(s)

On the basis of this assessment, competitive pressures within this sector are considered to be relatively stable, with healthy, but not excessive levels of competition. Commensurate stable pricing is therefore expected with some potential for downward pressure depending on new entrant attrition.

Electrical Equipment Supply

The supply of the electrical infrastructure associated with an offshore wind project can be characterised into two principal categories:

1. **High Voltage Electrical Equipment,** to be deployed at offshore and onshore substations, including but not limited to transformers, switchgear, reactive compensation and busbars; and,

2. **Subsea Cables**, for use in project collection (inter-array) and export systems.

The required High Voltage electrical equipment is in general sourced as standard products drawn from the broader power distribution industry. In this sense, the demand characteristics from the offshore wind sector are relatively insignificant when set in the context of the global power distribution equipment market. Whilst historically and indeed, currently, there are significant lead times associated with the procurement of certain items such as high voltage transformers, in general this has little impact on pricing - again this being symptomatic of drawing supply for a larger and more mature industry.

Specialist high voltage power cables are required for offshore deployment and these have been developed primarily for use in the offshore Oil & Gas sector, as well as for domestic and transnational power transmission. Given the specialist nature of subsea cables, historically they have represented a pinch-point in the supply chain for offshore wind, with consequent upward pressure on pricing. however, there is strong evidence that the leading suppliers of subsea cables at inter-array and export voltages have recognised that offshore wind sector will come to represent the single largest client group and that the growth in this sector warrants investment in additional production capacity.

On the basis of these arguments, it is considered that pricing for electrical equipment and subsea cables is likely to remain stable over the next decade, with some potential for moderate downward or upward pressure, depending supply and demand fluctuations.

Installation

The supply of installation vessels for offshore wind projects can be categorised into three main types of operation:

1. **Wind Turbine Foundation Installation,** generally undertaken from a jack-up type vessel with some potential for utilisation of floating barges;

2. **Wind Turbine Erection**, exclusively from jack-up type vessels; and,

3. **Wind Turbine Repair Operations,** wherein for major operations jack-up vessels are required.

GLGH maintains a database of current and planned installation / repair vessels for the offshore wind sector including those that have previously been diverted from other industries as well as bespoke designs. Using this database, future supply-side capacity has been projected for 4 scenarios:

- **Firm Capacity,** consisting of existing dedicated offshore wind installation vessels, those which are under construction or contract as well as a proportional of resource availability from other industries (coastal engineering and offshore O&G);

- **Low Case**, consisting of firm capacity with an addition 2 new bespoke dedicated offshore wind installation vessels becoming available from 2015;

- **Mid Case**, consisting of firm capacity with the addition of up to 5 new bespoke dedicated offshore wind installation vessels becoming available by 2020; and,

- **High Case**, consisting of firm capacity with the addition of up to 10 new bespoke dedicated offshore wind installation vessels becoming available by 2020

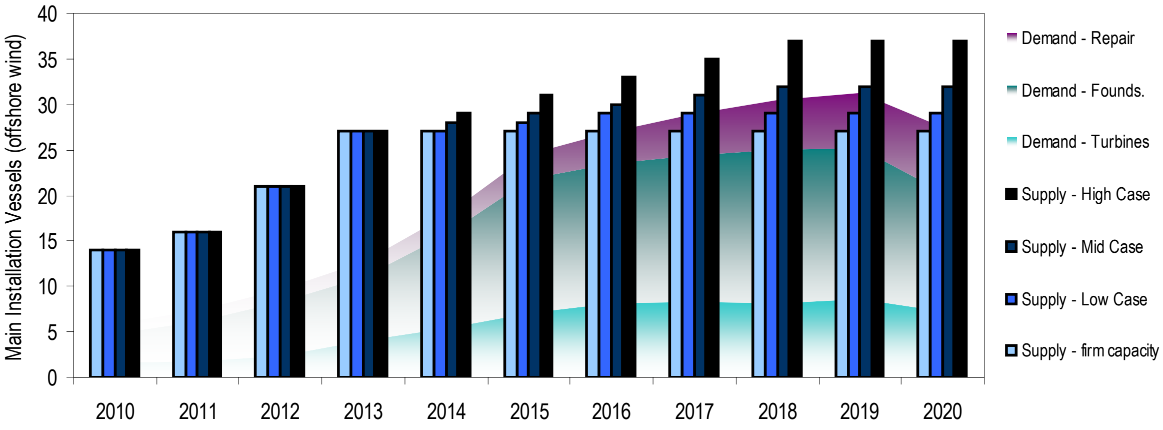
Of these scenarios, the Mid Case is considered to be the most likely / realistic.

Other key activities include specialist vessels for installation of subsea cables and heavy lift vessels for the installation of offshore substation foundations and topsides. Consideration of the slightly less critical operations is excluded from the current assessment.

The GLGH Offshore Wind Farm Projects Database, as described further in Appendix 1, has been used to project demand characteristics for the offshore wind sector in the primary markets for each of the three major operation categories described above.

Projected supply and demand are compared graphically in Figure 2.14 below.

Figure 2.14. Projected Offshore Installation Supply and Demand



In general, it can be seen that supply is expected to significantly exceed demand on average during the period to 2015. Following this, as demand ramps up, there appears to be potential for a significant pinch-point demanding on the extent of new capacity coming on line. The lead time associated with a new main installation vessel is of the order of 24 months. However, the potential for resource entrainment from depressed O&G and coastal engineering sectors should not be underestimated. Overall, the analysis indicates healthy competitive conditions in the short to medium term followed by the potential for upward pressure on pricing thereafter.

2.3.3 Trends in other Drivers

Commodities

On the basis of the driver sensitivity investigations presented in sections 2.2.5 to 2.2.7, the outlook for the key commodities for offshore wind project costs may be summarised as follows:

- **Steel** markets are currently experiencing moderate to strong upward shifts with the 10 year outlook expected to be stable to declining. There are very substantial levels of uncertainty associated with this market.

- **Copper** markets are currently at record highs with the 10 year outlook expected to exhibit downward trends with sporadic and sustained spikes. There are very substantial levels of uncertainty associated with this market.

- **Oil** markets are currently the subject of substantial upward trends with the 10 year outlook expected to be a stable to upward trend with substantial levels of uncertainty.

Changing Project Characteristics

On the basis of the driver sensitivity investigation presented in Section 2.2.8, it is considered that the increased technical demands associated with the average increases in maximum water depth and distance from shore will cause a moderate to substantial upward trend in project costs over the next 10 years. Some of these additional costs may be offset by increased economies of scale on an individual project basis, with some degree of improved fixed cost spreading and process efficiency expected.

Scale, Learning and Innovation

On the basis of the driver sensitivity investigation presented in Section 2.2.9, it is considered likely that scale, learning and innovation effects will cause some level of downward pressure on project costs over the next 10 years. The extent of such savings will depend on the following key factors:

- The efficacy of the industry in bringing innovation forward to market readiness;
- The inherent level of residual cost savings possible in relation to scale, learning and innovation effects, which is an area of particular uncertainty; and,
- The healthy degree of competition within the supply chain which is considered to be a prerequisite for ensuring that cost savings are passed on to the project.

2.3.4 10-year CapEx Projections

Average capital cost trends have been projected for the period 2010 - 2020 on the basis of the cost driver sensitivity exercise presented in Section 2.2, the supply-demand analysis presented in Section 2.3.2 and the expected trends for other drivers as presented in Section 2.3.3. Three future cost scenarios (central, high and low) have been considered via the indicative quantitative prediction of relative trends within each of the cost drivers assessed in this study. The qualitative rationale for the trends assumed in each case is outlined in Table 2.9, with quantitative results presented in Table 2.8 and Figure 2.15.

Table 2.8:. Headline 10-year CapEx projections

Scenario	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Central Scenario (Trend)	0%	-2%	-5%	-10%	-13%	-14%	-14%	-16%	-16%	-17%	-17%
High Scenario (Trend)	0%	2%	5%	9%	13%	16%	17%	18%	17%	18%	18%
Low Scenario (Trend)	0%	-2%	-14%	-19%	-22%	-26%	-28%	-29%	-31%	-32%	-32%
Central Scenario[1] (mDKK / MW)	26.0	25.5	24.7	23.5	22.5	22.2	22.3	21.9	21.7	21.7	21.7
High Scenario[1] (mDKK / MW)	26.0	26.6	27.4	28.3	29.3	30.3	30.4	30.6	30.5	30.7	30.6
Low Scenario[1] (mDKK / MW)	26.0	25.4	22.4	21.2	20.2	19.3	18.8	18.4	17.8	17.8	17.8

1 Assume 2010 headline market rate of 26 mDKK / MW.
2 All values are referenced to 2010. No allowance for future underlying inflationary trends have been made.

Table 2.9: Rationale for assumed 10-year trends

Cost Driver	Rationale for assumed trends		
	Central Scenario	High Scenario	Low Scenario
WTG Supply	Stable pricing in short-term as incumbent OEMs fight for market share with persistent downward pressure thereafter, exerted from new entrants.	Very high attrition rate limits new capacity with shift to larger WTGs causing an inherent rise in the cost base.	Significant ramp-up in competition in short-term with persistent downward pressure on prices following oversupply.
Vessel Supply	2010 represents the top of the market with day rates gradually decline as new build capacity comes online - stabilising from 2015.	Failure of majority of new builds to materialise leads to upward pressure on pricing with stabilisation from 2015.	Oversupply situation in short to medium terms leading to crash in prices with consistent downward pressure from 2015.
Competing National Markets	Considered as neutral (no change) in central case. Only a significant factor when supply << demand across sector.	Under a supply constrained scenario, resource is diverted to the most profitable national markets - upward pressure.	Considered as neutral (no change) in central case. Only a significant factor when supply << demand across sector.
Oil (secondary impact thereof)	Commodities markets considered as (neutral) in central case due to huge uncertainties in forecasts.	Increasing and sustained high oil prices leads to significant diversion of installation assets and upward pressure on day-rates.	Lack of consistent O&G activity leads to additional resource availability and modest downward pressure on pricing.
Changing Project Demands	Gradual ramp up over decade to middle of estimated sensitivity range.	Gradual ramp up over decade to upper bound of estimated sensitivity range.	Gradual ramp up over decade to lower bound of estimated sensitivity range.
Foundation Supply	Short-term increase in competitive pressure followed be slight reversal as deeper projects are forced towards certain specialist concepts.	Failure to attract as many new entrants as possible leads to general undersupply with significant upward price pressure from 2015.	Short-term increase in competitive pressure with several new entrants in period to 2015 - supply generally well above demand.
Scale, Learning and Innovation	Steady decline over decade to middle of estimated sensitivity range.	Delayed and diminished benefit over decade converging towards upper end of estimated sensitivity range.	Steady decline over decade to lower end of estimated sensitivity range.
Steel	Commodities markets considered as (neutral) in central case due to huge uncertainties in forecasts.	Consistently high steel prices cause sustain upward price pressure.	Stable to depressed steel market causes slight downward pressure from 2010 levels.
Electrical Equipment Supply	Slight downward pressure from reasonable levels of competition in short-term, followed by stabilisation from 2013.	Slight upward pressure from low levels of competition in short-term, followed by stabilisation from 2013.	Downward pressure from reasonable levels of competition in short-term, followed by stabilisation from 2013.
Copper	Commodities markets considered as (neutral) in central case due to huge uncertainties in forecasts.	Consistently high copper prices cause sustain upward price pressure.	Stable to depressed copper market causes slight downward pressure from 2010 levels.

Figure 2.15: 10-year CapEx Projections with individual driver contributions

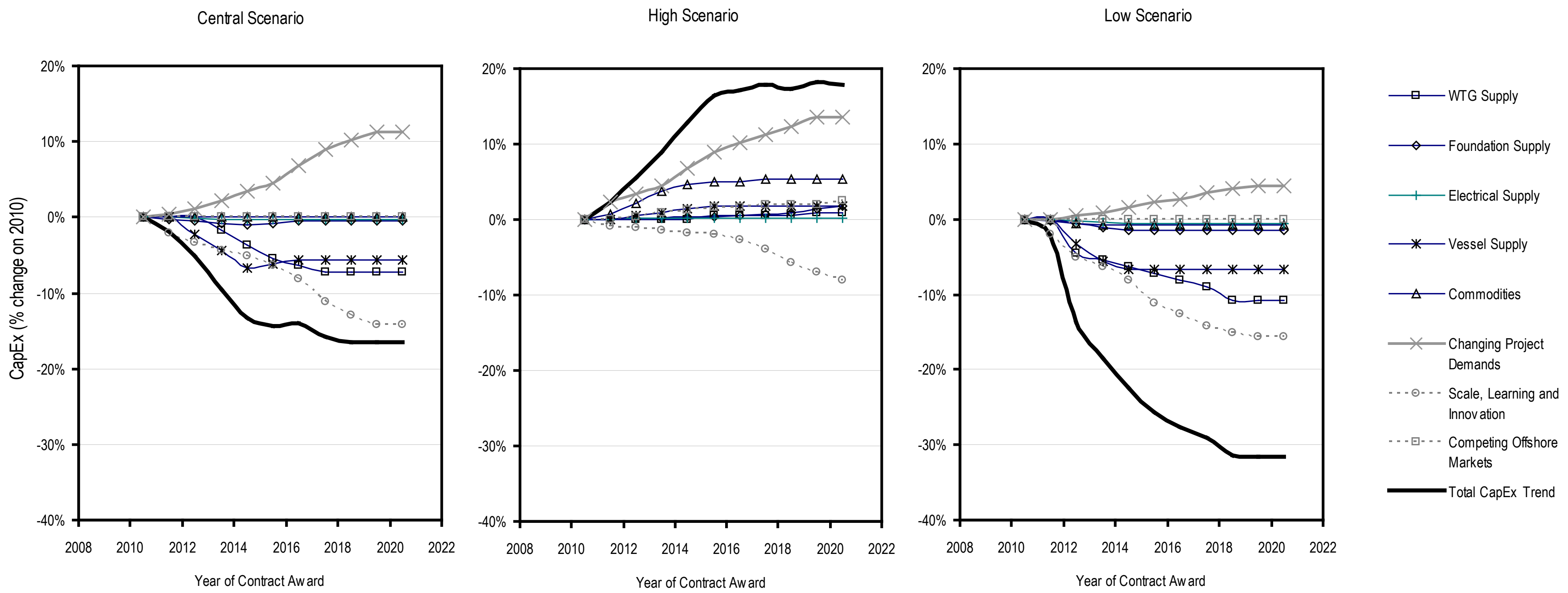
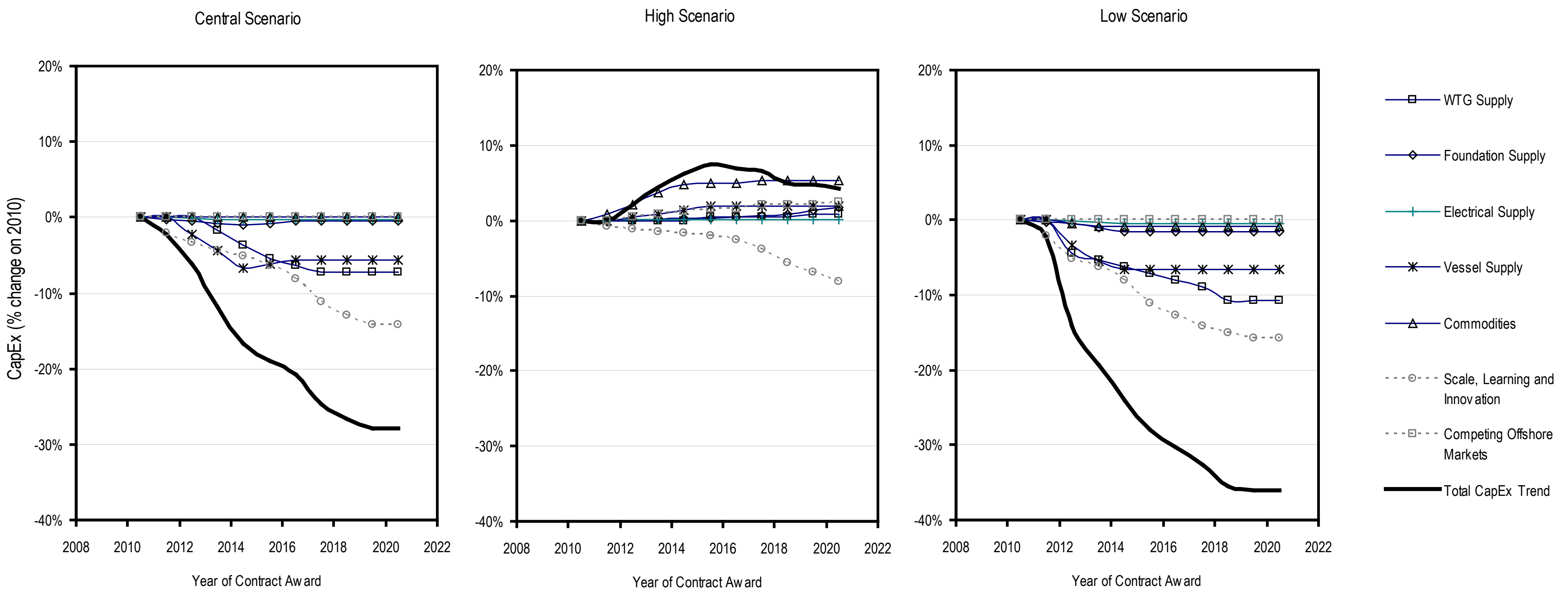


Figure 2.16. 10-year CapEx Projections with individual driver contributions (neglecting Changing Project Demands)



The 10-year CapEx Projection analysis has been repeated, neglecting the affect of the Changing Project Demands driver since this driver is unlikely to be relevant for Denmark in the forthcoming years. The results of this variation analysis are presented in Figure 2.16 above and Table 2.10 below.

Table 2.10. Headline 10-year CapEx projections (neglecting Changing Project Demands)

Scenario	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Central Scenario (Trend)	0%	-2%	-6%	-12%	-17%	-19%	-21%	-25%	-27%	-28%	-28%
High Scenario (Trend)	0%	0%	2%	4%	6%	7%	7%	7%	5%	5%	4%
Low Scenario (Trend)	0%	-2%	-14%	-19%	-24%	-28%	-30%	-33%	-35%	-36%	-36%
Central Scenario[1] (mDKK / MW)	26.0	25.4	24.4	22.9	21.6	21.1	20.6	19.6	19.1	18.8	18.8
High Scenario[1] (mDKK / MW)	26.0	26.0	26.5	27.1	27.6	27.9	27.8	27.7	27.3	27.2	27.1
Low Scenario[1] (mDKK / MW)	26.0	25.4	22.3	21.0	19.8	18.8	18.1	17.5	16.8	16.6	16.6

1. Assume 2010 headline market rate of 26 mDKK / MW.
2. All values are referenced to 2010. No allowance for future underlying inflationary trends have been made.

2.3.5 Findings

The following findings are drawn on the basis of the analysis presented above:

- Offshore wind project capital costs are projected to reduce by up to 32% over the next decade, with a central (most likely) estimate of 17%. Under specific market conditions, offshore wind CapEx could rise by up to 18%.

- Cost reductions via scale, learning and innovation effects are predicted to largely offset cost increases associated with project sites being located further from shore and in deep waters. Other than these drivers, trends in supply chain dynamics and specifically in the WTG Supply and installation markets, dominate the future cost trend projections.

- The outlook for both these key supply markets is considered to be healthy from the perspective of project developers, with supply expected to stay well ahead of demand in the short to medium term. However, there is significant uncertainty associated with this assertion given the credible possibility of a loss of supply chain confidence, should project roll-out momentum stall in the critical UK and German national markets.

3. Competition for offshore wind development sites

3.1 Supply of Development Sites

Due to the predominantly publically controlled nature of the seabed around most countries, the supply of site allocations for offshore wind farms is typically managed more centrally than is the case for onshore wind projects. Supply is influenced via existing regulations surrounding seabed ownership and consenting procedures and the existence (or lack thereof) of political will for opening it up to offshore wind development.

Concession arrangements can be categorised along a spectrum ranging from an entirely open-door approach whereby any location can be selected by the market provided all consenting hurdles can be negotiated, through to strict single-site tendering whereby location is selected and concession managed by state bodies. A number of mid-way approaches have also been adopted by competing markets including periodic "rounds" of multi-site tenders, open-door site selection but with tendering for financial support thus limiting site supply de-facto, and open-door applications followed by enforced competitive tendering for the chosen site. Table 3.1 presents the position of the concession models adopted by leading European offshore wind markets along this spectrum. Site selection in markets to the left is dictated by the state while those to the right are selected by industry.

Table 3.1. Site concession models in European markets

Single site tender	Multi-site tender	Open selection, tender for support	Open selection, tender for concession	Open-door concessions
•Denmark (DK)	•UK	•Netherlands (NL) •France (FR)	•Spain (ES) •Belgium (BE)	•Germany (DE) •Ireland[1] (EI) •Sweden (SE)

1 Ireland has an open door concession and consenting model but an *ad-hoc* grouped selection process for grid connections which results in site supply characteristics similar to a tender model.

It is important to consider the above table when assessing site supply both in terms of existing allocations and new allocations expected over the course of the next decade. A number of countries either have defined national offshore wind targets and/or expected capacity installations outlined in their respective National Renewable Energy Action Plans (NREAP) for meeting EU 2020 renewable energy targets. These targets or estimations are summarised in Table 3.2. Where the figures differ a star indicates which of the targets is perceived by GLGH to be the principal driver for government policy.

Table 3.2. National market's offshore wind targets

National Market	DK[1]	UK[2]	NL[3]	FR	ES	BE[4]	DE	EI[5]	SE[6]
2020 Offshore Wind Target [GW]	2.3*	33.0	6.0	6.0	3.0	-	10.0	-	4.0
2020 NREAP Offshore Wind Allocation [GW]	1.3	13.0*	5.1*	6.0	3.0	1.5*	10.0	0.6*	0.2*

For countries which rely on a tender model, site concession for areas of seabed sufficient in size to achieve targets will need to be provided via ad-hoc tender rounds driven by the necessary political will. Countries with the open-door approach instead will need to rely exclusively on ensuring their concession, consenting and support mechanisms are designed to facilitate adequate build-rates.

Existing site allocations in terms of the installed capacity they are reasonably able to accommodate, are presented in Figure 3.1. Figure 3.2 then compares these allocations against the 2020 national targets identified as the principal driver in Table 3.2 above.

[1] The Energy Strategy 2050 produced by the Danish Government in February 2011 indicates tenders will be held prior to 2020 for the 600 MW Kriegers Flak project and 400 MW of smaller projects nearer to shore. These figures added to existing installations and the contracted Anholt Wind Farm give 2.3 GW total by 2020.

[2] The 33 GW target was espoused by The Crown Estate (TCE) upon the launch of the UK Round 3 tender. TCE manage seabed concessions but are not in control of UK renewable energy policy. No official target exists for offshore wind as government policy, however the NREAP figure can be taken to be reasonably representative of expectations. Figures do not include deployments on the seabed of Northern Ireland.

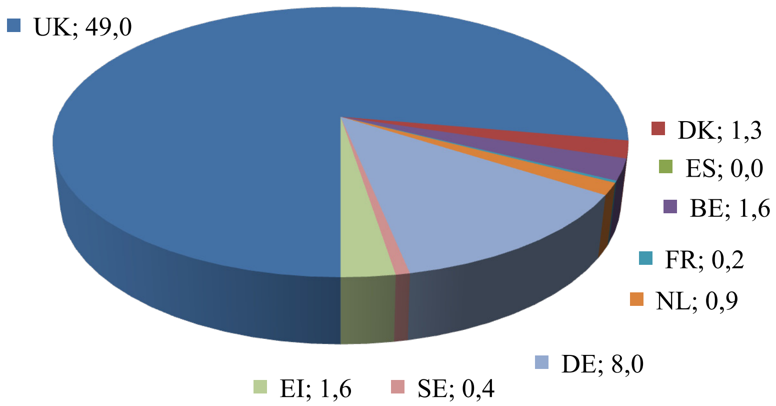
[3] The 6 GW target was first articulated in 2001, however the new Coalition Government in the Netherlands states that the EU targets are the primary objectives suggesting they foresee a build-out more along the lines of the NREAP.

[4] Belgium has no official target for offshore while the NREAP provides a scenario of 4 GW total wind capacity (offshore and onshore) by 2020. The Flanders Wind Energy Association predicts 1.5 GW offshore by 2020 and this would seem a reasonable proportion of the NREAP total.

[5] Ireland has no official target for offshore wind. The NREAP quota of approximately 600 MW by 2020 is reasonable considering current permitting and grid connection allocations. Note the two projects currently in possession of full site concession and consent (Arklow Phase II and Codling Wind Farm) are not expected to be commissioned prior to 2020. The 600 MW figure is more likely to be reached via the commissioning of other sites yet to receive concession and consent but which were included in the "Gate 3" grid connection offer process.

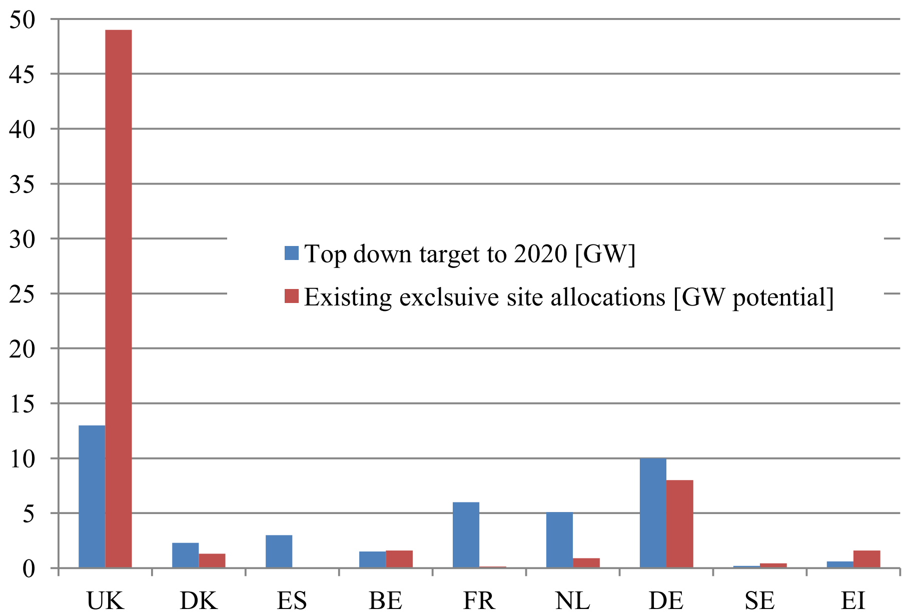
[6] The Swedish Parliament approved a target of 30 TWh to be produced from wind power by 2020 with one third coming from offshore projects, equating to approximately 4 GW of installed capacity. However the current lack of a specific financial support mechanism for revenue derived from offshore wind projects will almost certainly render such a target unachievable. Therefore assuming no change in policy occurs regarding financial support the NREAP figure can be assumed to be closer to true expectations.

Figure 3.1. Existing site allocations by market [GW potential]



Note: Netherlands figure excludes 2.7 GW of current allocations set to expire in 2012

Figure 3.2. Existing site allocations against national offshore wind targets



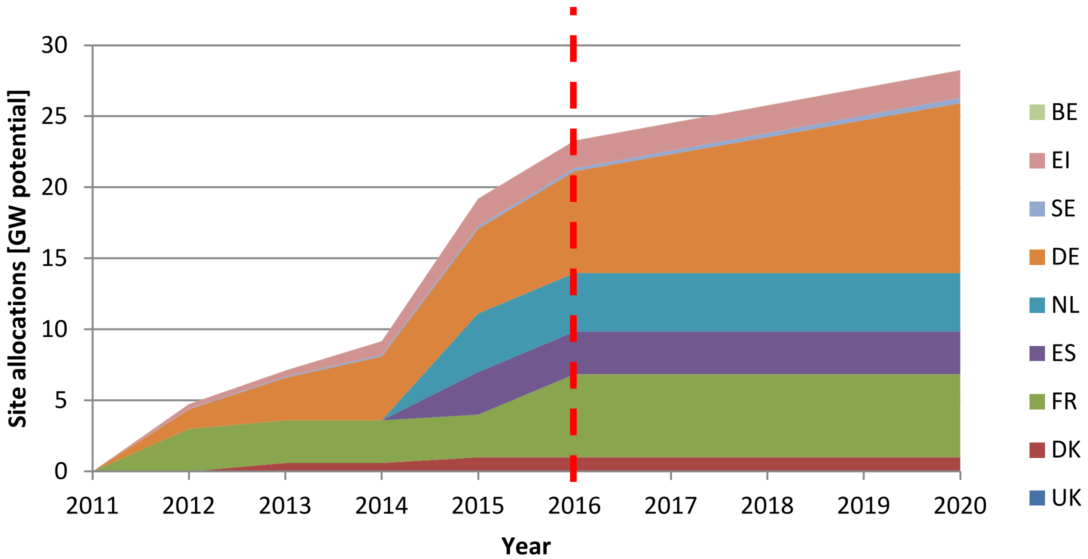
The graphs clearly present not only the overwhelming dominance of the UK in terms of site concessions to date, but also the fact that concessions have been agreed for a seabed area with the potential for far greater installed capacity than the UK 2020 targets. An important qualifier to this is that the UK awards exclusive site concession prior to consenting procedures. The level of attrition to the allocated quantity noted in Figure 3.2 can therefore be expected to be substantially greater than for markets where consenting is a prerequisite, or intrinsically linked, to concession. Furthermore due to concession being awarded relatively early in the site development process, much of UK Round 3 capacity will end up being developed post-2020. Nevertheless even accounting for these qualifiers, it seems clear that there will be little political need for significant further UK site supply over the coming decade.

Germany too has already allocated site permits for 8 GW potential capacity, equivalent to 80 % of its 10 GW 2020 target. A further 9 GW of applications are in the pipeline, and while some of these are for overlapping sites (automatically guaranteeing a level of rejection), it seems likely the majority of fresh applications lodged in the coming years will be for sites intended to be commissioned post-2020.

The Netherlands, France and Spain on the other hand will all require fresh tenders worth a number of GigaWatts each if they are to meet 2020 targets. It is these markets alongside a drip-feed of open-door applications in German waters and exchanges of site leases already granted in the UK, that any Danish tenders held prior to 2020 will compete with for the residual developer demand (See Section 3.2).

Assuming no changes are made to 2020 targets for offshore wind capacity in the European countries under consideration here, and assuming concession models remain unchanged, a plausible timetable for site concessions which would allow all countries to meet their 2020 targets/estimations is provided in Figure 3.3 below. The graph assumes an attrition rate of one third rejections to German permit applications currently lodged with the successful two-thirds accounting for almost all German allocations predicted to be awarded prior to 2016. The allocation rate for 2015/2016 is then assumed to continue through to 2020 as awards are given to new applications yet to be lodged at present. With respect to the other two markets with the open-door concession model, the same approach and assumptions are made for Sweden as for Germany while for Ireland all current applications are assumed to be accepted although no fresh applications are expected to be lodged due to grid connection restrictions.

Figure 3.3:Indicative plausible site allocation timetable



Note that any site allocation intended to assist in meeting 2020 targets is likely to be required at least 4 to 5 years prior to 2020 to allow adequate time for contract negotiation, wind farm design and construction works. Thus the dashed red line on the above chart at 2016 indicates an approximate limit on concession awards for commissioning intended prior to 2020. For this reason the above chart assumes Dutch, French and Spanish tenders of sufficient quantity to meet national targets take place in the middle of decade (political and grid barriers are expected to prevent tenders taking place much earlier). Even within this timeframe a substantial part of consenting and initial site studies would be required to have taken place prior to tender. Otherwise, depending upon the concession model in place, tenders may have to take place significantly earlier still, for example in the UK where permitting is sought subsequent to receiving a site lease. The possibility of further tenders taking place prior to 2020 but intended to meet post-2020 capacity expansion has not been considered here.

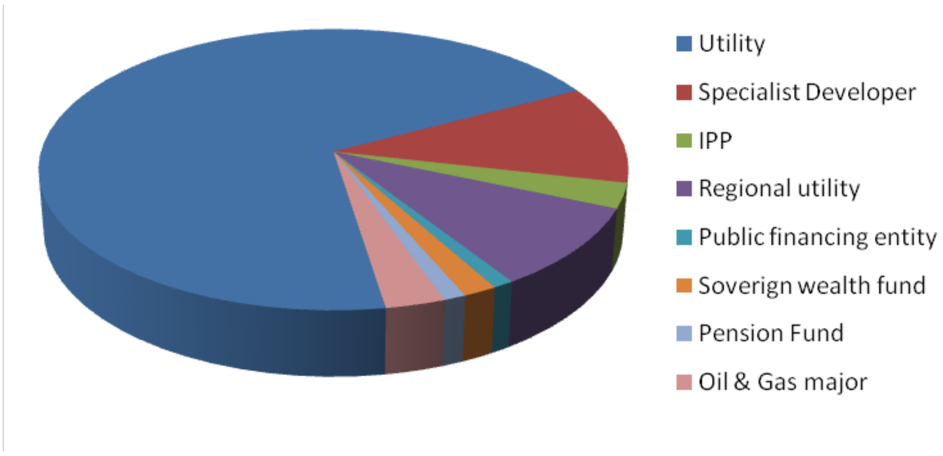
The above charts can therefore be used as a first run estimate of new site supply for European offshore wind sites intended for commissioning by 2020. With adequate political will to meet national targets, up to 23 GW of new site allocations may be estimated to be tendered or allocated by 2016 of which approximately 8 GW is estimated to come from existing German and Irish permit applications. This would leave around 15 GW for potential new applications. An additional market is also likely to arise from UK Round 3 and Scottish Territorial Waters site leases being exchanged as tender winners abandon allocations which could generate further competition for a future Danish tender.

In addition to the markets analysed above which represent those most active in the offshore wind industry to date, notable development pipelines which GLGH currently expects to deliver around 3 to 4 GW of installed capacity combined by 2020 exist in the four tertiary markets of Italy, Finland, Norway and Northern Ireland.

3.2 Demand for Development Sites

In general the development phase for wind farm sites may be undertaken either by specialist developers (who ultimately sell some or all equity prior to construction), independent power producers (IPPs) or utilities. The latter two of these categories along with outside investors (both private and institutional in nature) also make up the ownership of operating wind farms. In onshore wind the regional market strength of incumbent electricity generators and low technical barriers to entry have allowed the developer and owner landscape to shift and expand alongside the geographical expansion of wind farm installations. Nevertheless after gaining substantial experience in their domestic markets many of the larger IPPs and more renewables-driven utilities are now looking to aggressively expand in the new markets of Eastern Europe and offshore in Northern Europe. Given the scale of the investment necessary for offshore projects, ownership during construction and operation is increasingly limited to large corporations, the overwhelming majority being utilities as shown in Figure 3.4.

Figure 3.4. Operational, under construction and contracted offshore wind capacity by owner

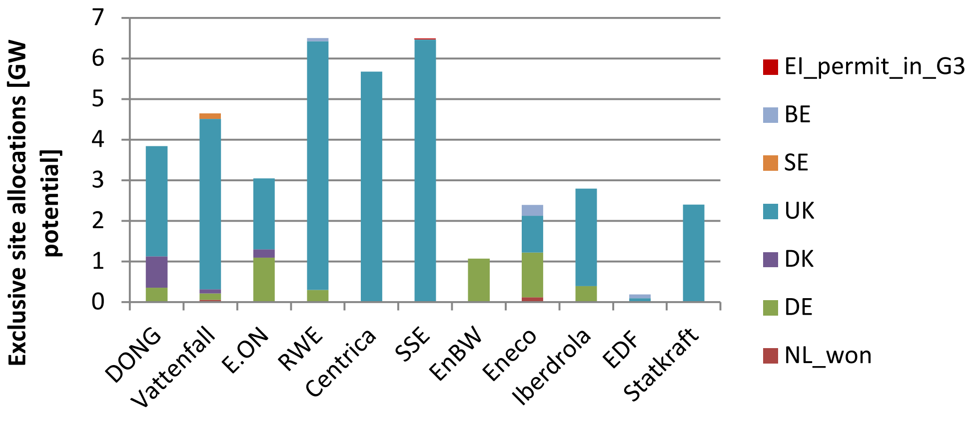


The demand for new sites among these potential owners is assessed below.

Major utilities active in offshore wind

Utility appetite for site concessions is driven by the economic viability of offshore wind compared to the alternatives, by strategic market positioning and by the absolute level of capital and personnel capacity available to them to pursue opportunities. Current site allocations inclusive of all operational projects, projects under construction and proposed projects in possession of exclusive site concession for major utilities involved in offshore wind development, is provided in Figure 3.5.

Figure 3.5. Existing site allocations of major utilities



Note 1: Given the constraints imposed by the Gate 3 connection round only projects with full concession and a firm connection offer from the Gate 3 process have been included for Ireland.

Note 2: All site concessions which did not receive a subsidy under the 2009/2010 tender in the Netherlands will expire in 2012. The likelihood of a further tender round prior to 2012 is slim and thus these concessions are not included here.

Assessing appetite for further concessions from utilities is clearly a highly subjective process. A number of firms provide related corporate targets or expected expenditure on renewable projects from which approximate estimations can be derived as detailed in Table 3.3 below.

Table 3.3. Assessment of demand for offshore wind development to 2020 among major utilities

Utility	Published offshore wind expectations	GLGH interpretation of 2020 offshore wind expectations
DONG	3 GW wind by 2020	DONG's focus to date has been over 90 % towards offshore projects so 2020 target can estimated at **2.7 GW**
Vattenfall	49 TWh wind by 2030	Interpolating from 3.7 TWh in 2010 and assuming two-thirds capacity offshore provides an estimate of **6.7 GW** capacity in 2020.
E.on	10 GW renewable capacity by 2013	Interpolating from 4 GW as of 2010 and assuming 40% new capacity is offshore wind would give **8 GW**. However statement that concentration will be on "operational performance" suggests assuming such a linear build-out could overstate expectations.
RWE	Renewable pipeline of 16.7 GW with approximately 6 GW offshore wind	Assuming current pipeline is approximately equivalent to 2020 roll-out expectations **6 GW** offshore wind by 2020.
Centrica	Total investment on offshore may be over £9 billion by 2020 shared with partners on 5.8 GW	The language suggests Centrica expects current allocations with **5.8 GW** potential to account for all its pre-2020 offshore wind activities.
SSE	Expect to spend £1.5 billion over next 5 years and have offshore wind pipeline of 8 GW	The language suggests SSE expects current allocations with **7.2 GW** potential to account all or most of its pre-2020 offshore wind activities.
EnBW	20 % generation from renewable by 2020 (double current level)	Require 8 TWh worth of extra renewable generation over next decade to meet target. Assuming all is from wind and 80 % offshore would result in **2.4 GW** new offshore capacity.
Eneco	Current pipeline with capacity over 2 GW	Announced interest in over **6 GW** worth of potential sites in Netherlands. Slow progress on concessions in home market could see attention focus elsewhere.
Iberdrola	Current pipeline of 8.4 GW and intends to "take strong offshore position medium term"	Assuming a proportion of UK and Spanish development pipeline expected for post-2020 build would result in 2020 expectations of around **5 to 6 GW**.
EDF	Reported as stating they will bid jointly with Alstom in current French tender.	Future offshore wind capacity expansion interest noted only in French market. Dominant position here could see **2 to 3 GW** by 2020.
Statkraft	150 MW by 2015	Interest only noted thus far for Statkraft's UK pipeline of **2.4 GW** much of which may be developed post-2020

Care must be taken when interpreting the above numbers but a general range of 2 GW to 8 GW per major utility currently active in offshore wind appears a reasonable estimation of appetite for development from this source by 2020. Reading the declarations it is clear that the existing site allocations of a number of utilities such as Centrica, SSE and DONG could potentially match their 2020 offshore wind generation expectations. The bulk of a majority of these pipelines consists of site leases awarded through the UK Round 3 tender. It should also be noted that these utilities may expand their portfolios via purchasing sites from specialist developers such as Mainstream Renewable Power who were awarded a share worth 2 GW potential from the Hornsea development zone during the Round 3 tender.

One possible interpretation of this situation is that these UK Round 3 leases have led to a near saturated market demand for site supply among many of the major utilities active in offshore wind. In this market context it is unsurprising to hear comments that the focus of these companies' attention is on Round 3 developments and any further European tenders, particularly from smaller peripheral markets, are required to be especially attractive to gain interest. It may therefore take a number of years of slow supply for demand to rebuild as development teams and capital for investment are freed-up.

Additional reasons beyond those cited above to explain why utilities may be interested in further site concession opportunities prior to 2020 include:

- **Home market advantage:** A number of Europe's largest utilities were born from, or remain as, state-owned entities. They therefore typically have unique interest in their home markets and will pay increased attention to opportunities within them. For example interest in tenders has been notably strong from EDF in France, Iberdrola in Spain, Eneco in the Netherlands and DONG in Denmark. Against this, increased electricity market liberalisation may lead to increased geographical diversification in some cases.

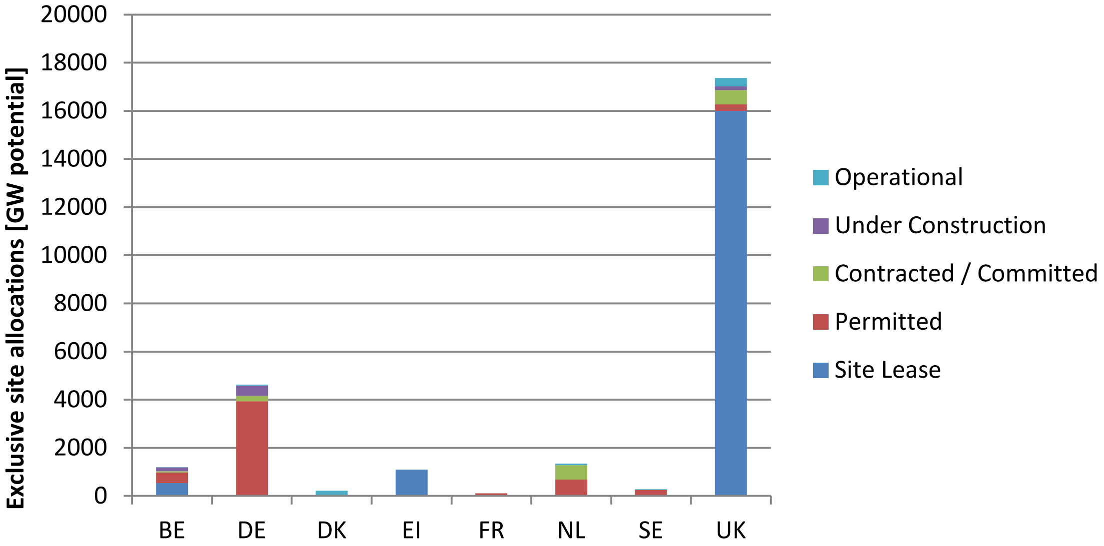
- **Balanced Portfolio:** Political and policy risk are enhanced by dependence on a single market to deliver targets. The current consultation in the UK on changes to the support mechanisms for renewable energy highlight the risk involved in potential over-dependence by utilities on a single national market.

Other players

As noted above while a relatively small number of major utilities dominate the current project pipeline for offshore wind, there is a degree of current development and ownership by other types of entities, notably oil and gas majors. Smaller specialist developers and IPPs using project financing routes have long been a significant feature of the onshore wind market but struggled to access the required funding to enter the offshore industry. A number of ownership routes from outside the pure energy industry have also arisen including sovereign wealth funds, pension funds and private equity funds.

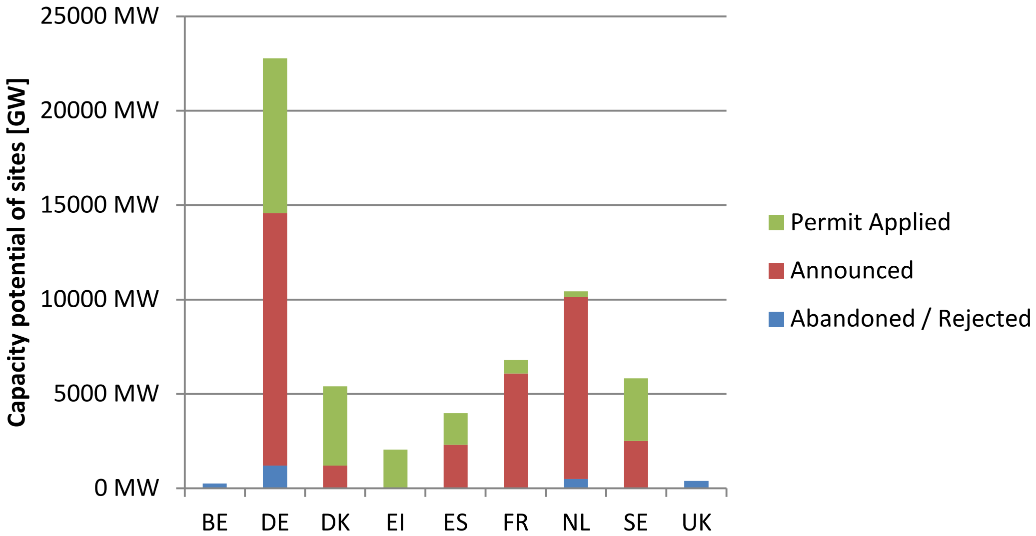
Figure 3.6 below presents all current exclusive site allocations for proposed or operating offshore wind farms whose owners do not belong to the major utilities described above. In total this accounts for approximately 26 GW of potential capacity.

Figure 3.6. Existing site allocations of other players



One indicator of the demand for further site allocations can be found in analysing all announcements of planned site investigations and development monitored by GLGH in the markets of interest. Figure 3.7 presents the estimated potential generating capacity of theoretical future wind farms based on these announcements, including those currently awaiting the results of site lease/permit applications.

Figure 3.7. Announced site developments (other players)



The above graph includes a cumulative total of approximately 59 GW proposed capacity. While less than 25 % of this pipeline is likely to be built, it demonstrates that significant interest in development of offshore wind sites exists beyond the major utilities if sufficiently attractive economics, manageable consenting and concession procedures and access to the necessary capital can all be secured. It is notable that Germany represents the bulk of this pipeline. This is in a large part due to German offshore wind being the second largest European market in absolute terms, while all announced UK projects already have exclusive site leases whereas in Germany concession takes place alongside permitting. However it could also be taken to reflect the traditional role of renewable energy generation in Germany being driven outside of the major utilities with involvement from smaller developers and regional utilities. Provision of financing routes for such players is a key concern of the German development bank, KfW, who are the subject of an ongoing initiative to ring-fence a substantial fund for offshore wind project-financing in the German market.

3.3 Confounding Influences

3.3.1 Availability of Finance

As noted above offshore wind has to date looked to major utilities to provide the financing required. However the current supply of sites has, largely due to the Round 3 process in the UK, saturated near-term demand in this sector. Utilities are constrained in their ability to finance new projects due to falling power prices, falling demand, high levels of debt from recent merger and acquisition (M&A) activity. They are also international firms with significant portfolios outside of Europe which will compete for their available capital.

Familiarity with tenders for large offshore energy projects combined with large balance sheets has attracted interest from oil and gas majors into offshore wind projects. Pension funds provide another potential source of equity but currently do not operate at scale in the renewable sector and have no history of involvement during the construction phase. Meanwhile project financing from banks has long been a staple of the onshore wind sector but the size and differing risk-profile of offshore projects combined with the recent financial crisis have constrained this route over the last few years. Novel solutions such as the creation of dedicated banks or funds lending at favourable terms under government support are being discussed in Germany and the UK. The role of the European Investment Bank (EIB) as well various export credit agencies has been significant in the handful of offshore wind projects to be debt funded.

Section 3.2 emphasised the current dominance of utilities (with some support from oil and gas players) in current development pipelines, but also showed that notable interest exists in offshore wind development from other types of organisation. Given the availability of capital from utilities is limited and the UK Round 3 process has done much to satisfy their near-term appetite for offshore wind development, expanding demand for new sites will depend on the success of lowering the actual or perceived technical and commercial risks for private sector finance particularly during the construction phase.

3.3.2 Supply Chain Imbalances

The effects of changing dynamics within the offshore wind industry supply chain will have a confounding influence on both the demand for, and supply of, site allocations. Section 2 of this report provides an analysis of supply-chain dynamics and other cost drivers within this industry.

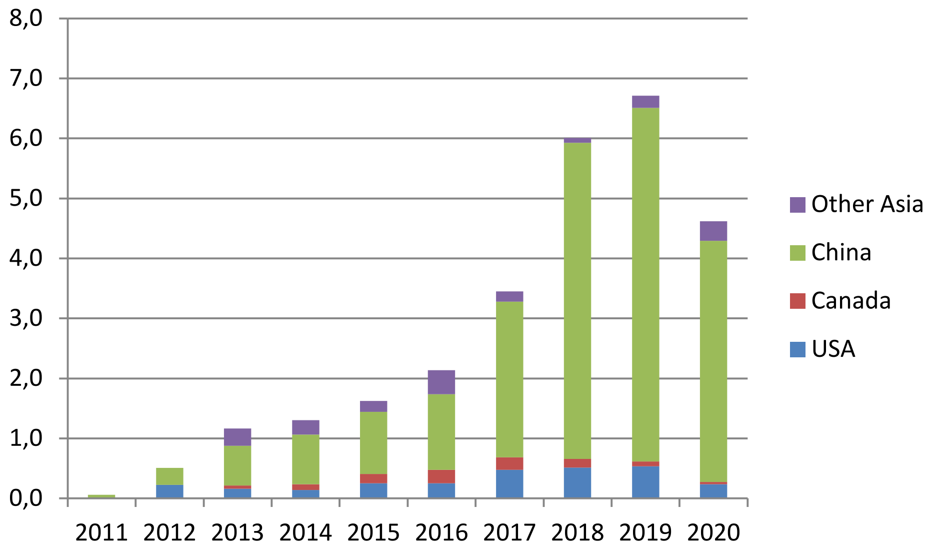
The direct effect of supply chain imbalances on demand for new site allocation is fairly straight forward – assuming a static support mechanism, rising costs will diminish returns and thus dampen demand. For supply the situation is rather more complex. If costs were to rise or remain above expectations due to supply chain shortages, then political support for offshore wind power may wane and tenders or support mechanisms be put on hold or diluted. The recent cooling on political attitudes towards offshore wind in the Netherlands could be seen as a result of increased negativity towards the technology following rising capital costs in the latter part of the last decade. The sensitivity of political support to changes in the cost-base of offshore wind generation will be dependent on the cost of alternatives, the political acceptability of alternatives (e.g. the need to meet EU targets; public opinion towards nuclear energy etc) and the technical viability of alternatives (e.g. resource levels, grid requirements). A large part of the UK's strong support for offshore wind can be explained via the difficulties associated with alternative options, for example public opposition to relaxing planning for onshore wind.

Section 3.1 identified potential future tenders in France, the Netherlands and Spain as likely to provide Denmark with the largest competition for demand over the next 5 years. However support for offshore wind in the Netherlands and Spain in particular could be described as particularly shallow at present and thus may be highly sensitive to any rising costs coming through the supply chain. Under such circumstances the 15 GW of potential new site applications and allocations by 2016 identified in Section 3.1 could reduce by half.

3.3.3 Other Emerging Markets for Offshore Wind

Outside of Europe most commercial development is expected to occur in China with a notable emerging market in North America and some demonstration projects in Korea. In the cases of China and Korea it seems likely that the vast majority of site development and associated supply will be sourced indigenously, ameliorating any potential resource conflicts for 1st tier supply. Almost all site development interest noted to date in North America has also come from local players, however from onshore experience it is reasonable to expect a greater degree of supply chain cross-over with Europe than is expected to be the case for Asia. Nevertheless as shown in Figure 3.8, capacity development projections for the US and Canada are expected to remain fairly insignificant when placed against European figures.

Figure 3.8. Offshore wind installed capacity projections for non-European markets



3.3.4 Uncertainty in Assumptions

By its to some extent speculative nature, the above analysis contains a number of significant uncertainties surrounding the assumptions made. These include but are not limited to:

- Interpretation of government targets where competing figures are given;
- Assumptions on success rate for permitting applications;
- Assumption that sufficient political will exists to provide the support required to meet preferred targets;
- Exclusion of the possibility other markets not considered here see sudden ramp-up in political support for offshore wind;
- Interpretation of utility appetite for offshore wind development based on statements given in Table 3.3;
- Sensitivity of demand by potential developers and owners to changing project economics; and
- Sensitivity of government support for offshore wind to changing economics.

Despite a high level of uncertainty, it is believed that the analysis describes a credible scenario for demand and supply of offshore wind development sites and is a useful basis for the modelling work to be undertaken in the business case calculations of the broader study.

3.4 Findings

The Round 3 tender of 2009 in the UK has largely shaped the current market for supply and demand of offshore wind farm site concessions. By allocating seabed area with the potential to contain installed capacity multiple-times the UK Government's 2020 NREAP expectations, alongside a relatively favourable financial support mechanism, demand among major utilities for new sites has been temporarily close to saturated. The landscape for further site concessions across Europe over the next decade does however look more constrained. France, the Netherlands and Spain all need to follow through with moderately sized tenders worth 3 to 5 GW each by the middle of the decade if they are to meet 2020 targets. Question marks remain however over the depth of the political support in these nations to holding such successful tenders. Should supply chain or other issues keep the cost of offshore wind above a desirable level (refer to Section 2.3.4) then even this limited supply of sites may be constrained further. Germany's open-door policy means concession is less dependent on ad-hoc political will, but an extensive pipeline of permit applications with the potential for installed capacity significantly in excess of its 2020 target means there will be little near-term opportunities for fresh applications.

In conclusion, demand for new sites among major utilities is likely to be muted for the next few years while attention and capital is focused on existing allocations, notably on UK sites. An exception to this appears to be interest in developments within former or current state-owned utilities' domestic markets, while the desire to balance policy risk through an international portfolio may also help pull some attention away from the UK. Demand exists among other players outside of the big utilities although access to finance remains a major barrier for those such as specialist developers or IPPs looking to take the project financing route. With uncertain and limited new supply of site concessions expected over the next 5 years demand may rebuild, while a financial recovery combined with the possibility of government-driven funds for low risk access to capital, will help facilitate the project finance route among non-utilities. The increased involvement and familiarity of pension funds and sovereign wealth funds with renewable generation may also assist in attracting additional equity from these sources.

4. Conclusions

The following conclusions and recommendations are drawn with respect to historical, current and future competitive trends within the offshore wind supply chain:

1. A review of the historical offshore wind capital costs reveals several important influences that have driven an upward spiralling trend from around 2005, which followed a period of relative stability from 2000 to 2004. Most important amongst these are those factors that have served to reduce supply chain competition, namely; the ongoing withdrawal of key contractors and products in combination with increasing demand pressure from industries competing for common supply capacity, in particular onshore wind. To reverse the upward CapEx trend in the long-term therefore, a reversal in supply chain trends is important. Another factor that has had a strong historical influence is the relatively high early competition between suppliers (2000-2004) and subsequent losses - as the true cost base and challenge of the technology was established and priced in to future contracts. Currency and commodity markets have also played an important role in driving CapEx for offshore wind.

2. Offshore wind project capital costs are projected to reduce by up to 32% over the next decade, with a central estimate of 17%. Under specific market conditions, offshore wind CapEx could rise by up to 18%.

3. Future cost reductions via scale, learning and innovation effects are predicted to largely offset cost increases associated with project sites being located further from shore and in deep waters. Other than these drivers, trends in supply chain dynamics and specifically in the WTG Supply and installation markets, dominate the future cost trend projections.

4. The outlook for both these key supply markets is considered to be healthy from the perspective of project developers, with supply expected to stay well ahead of demand in the short to medium term. However, there is significant uncertainty associated with this assertion given the credible possibility of a loss of supply chain confidence, should project roll-out momentum stall in the critical UK and German national markets.

The following conclusions and recommendations are drawn with respect to competition between project developers for future site allocations:

5. The market for offshore wind site allocation within the leading UK and German offshore wind sectors is considered to be relatively saturated, due to substantial awards / ongoing applications over the last 2-3 years.

6. The residual appetite for site allocations from the leading European utilities and O&G players, who now dominate the industry, is considered to be limited because of their existing commitments in the leading UK and German markets. However, residual demand from these companies is likely to be focused on domestic markets where strategic and political interests are likely to provide additional incentives for participation. Balancing portfolio risk is also a significant driver which is likely to strengthen this trend in some cases, particular for those utilities with a significant UK-bias at present.

7. There is potential for up to ~15GW of fresh site awards in the French, Dutch and Spanish markets, given an identified shortfall between national targets and existing allocation. However, the political will to realise these applications is in some of these market is uncertain.

8. Improved availability of project finance via government and EU-led initiatives is likely to lead to an increased involvement from non-utility investor classes and specifically, private equity, sovereign wealth and pension funds. The level of appetite from these sectors for site allocation is unclear at present.

9. Findings relating to residual developer appetite are subject a high degree of uncertainty because of the inherent limitations of the methodology adopted. It is recommended that existing consultation data obtained from some of the leading offshore wind developers be used to validate these findings. If necessary, further industry consultation should be considered in order to build additional confidence in the broad findings presented in this report.

APPENDIX 1

GLGH OFFSHORE WIND FARM PROJECTS DATABASE

GLGH tracks the status of all planned, in construction and operational offshore wind projects via continuous monitoring of public domain sources as well as information obtained during the course of commercial consultancy engagements. These data are captured in the *GL Offshore Wind Farm Projects Database.*

Each project is allocated an anticipated construction profile, which considers length of construction programme as well as likelihood of delays. The profile labels takes the following form:

[a]y[d]

where [a] = 1, 1+1, 2, 3 – number of years over which construction is predicted to spread (1 + 1 assumes a break between support structure installation and wind turbine installation);

and [d] = probability of delays, D (minor), DD (major), D3 (potentially prolonged), xD (highly uncertain program).

Each profile then has an associated timeline for construction activity over the years following the nominal construction year.

Table A.1 summarises the individual project installation scenarios (or profiles) in terms of support structure and wind turbine installation and whether installation is planned to occur over one, two or three years together with probabilities for delays. A probabilistic approach is taken, with the installation assumed to take up to six years (three years construction programme plus 3 years potential delays) in total plus an eight year profile for highly uncertain projects. Naturally this is not a rational approach for modelling individual projects, however when considering all projects together, this approach provides the most realistic and accurate analysis.

> As an example, profile *1yD* schedules installation of support structure and wind turbine in a single year, called year *X* for the sake of this example. However the Delay Probability mean that there is a 30% chance it will be delayed by 1 year and hence built in year *X+1*, a 10% chance it will be delayed by 2 years and hence built in year *X+2*, and consequentially a 60% chance it will be built in the planned construction year, *X*.

It should be noted that all activity profiles sum to 100%; the uncertainty associated with certain projects' construction is accounted for by the probability of construction value as described above.

Table A.1. Generic Wind Farm Installation Scenarios

	Support Structure Installation			Wind Turbine Installation			Delay Probability		
Profile	Year A	Year B	Year C	Year A	Year B	Year C	1 Year	2 Years	3 Years
1y	100%			100%					
1yD	100%			100%			30%	10%	
1yDD	100%			100%			35%	20%	5%
1yD3	100%			100%			30%	25%	20%
1+1y	100%				100%				
1+1yD	100%				100%		30%	10%	
1+1yDD	100%				100%		35%	20%	5%
1+1yD3	100%				100%		30%	25%	20%
2y	50%	50%			100%		30%	10%	
2yD	50%	50%			100%		35%	20%	5%
2yDD	50%	50%			100%		30%	25%	20%
2yD3	50%	50%			100%				
2yxD					8 year				
3y	30%	35%	35%		50%	50%			
3yD	30%	35%	35%		50%	50%	30%	10%	
3yDD	30%	35%	35%		50%	50%	35%	20%	5%
3yD3	30%	35%	35%		50%	50%	30%	25%	20%
3yxD					8 year				

Key to Profile name: [a]yD[b], where

[a] number of years: 1, 2 or 3

[b] probability of delays: D (minor); DD (major); D3 (potentially prolonged)

The activity probability profiles are shown graphically in the following set of figures: Figure A.1 for the support structure installation activity, Figure A.2 for the wind turbine installation activity and Figure A.3 for consequential wind farm power generation probability.

Figure A.1. Probability Distribution of Support Structure Installation Activity

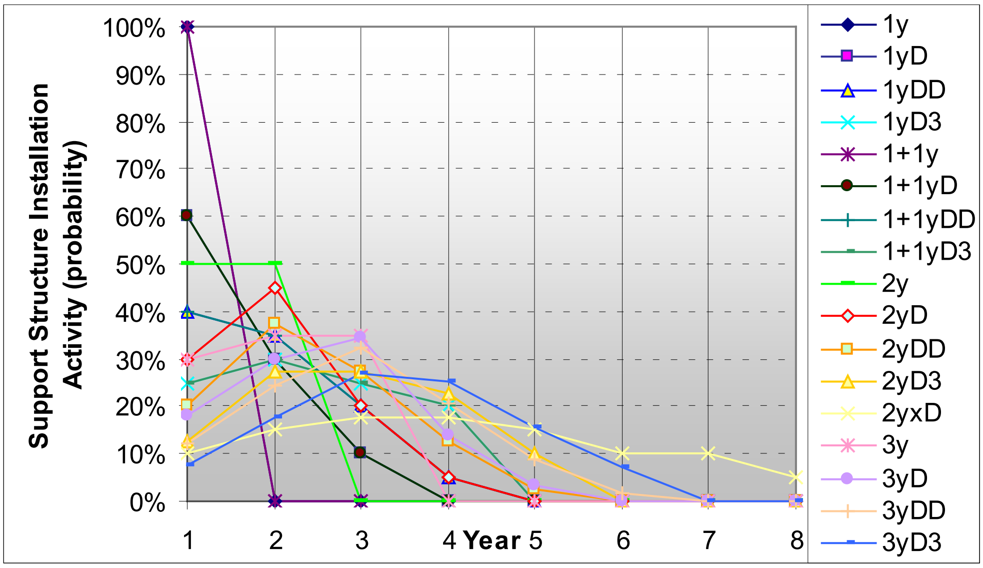


Figure A.2. Probability Distribution of Wind Turbine Installation Activity

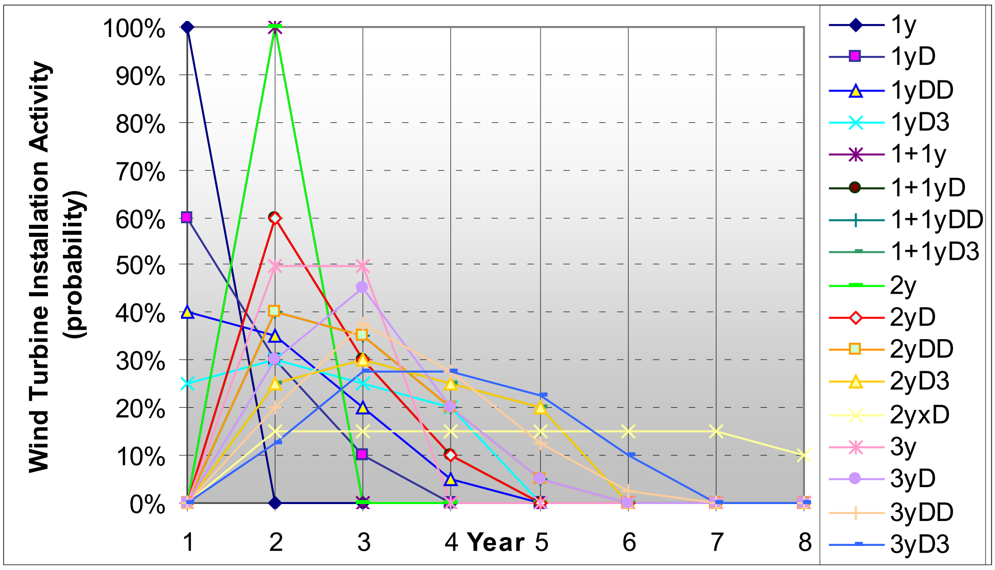


Figure A.3. Probability Distribution of Wind Farm Power Generation