BWEA

Delivering the UK's wind, wave and tidal energy

Winter 2007

UK Offshore Wind: Moving up a gear

UK Offshore Wind: Moving up a gear

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Foreword by Maria McCaffery MBE, CEO of BWEA

"Offshore wind in the UK is rapidly becoming one of the most exciting sectors in the global renewable energy industry. This country is poised to overtake Denmark as leader in the field, with projects now under construction approaching half of the current global offshore installed capacity – and the best is yet to come. The new confidence engendered by the publication of the Energy White Paper in May is palpable, and is in stark contrast to the uncertainty that reigned when BWEA published the report *Offshore Wind: At a Crossroads* in April 2006.

The remaining challenges should not be underestimated, however. As well as surveying developer attitudes following the White Paper, we wanted to repeat the *At a Crossroads* analysis in order to measure how the critical supply chain limits have developed, and how they might develop in the future. We believe the results show that, while there is no room for complacency, with the prospect of a stable, growing market, suppliers will come forward with turbines, other plant and services in appropriate quantities. We look forward to working with all parties to make this vision a reality.

With the largest market for offshore wind in the UK, there are huge opportunities available for British jobs and economic development, including export potential. This is recognised by our partners in this project, who have all contributed in order to ensure that the best information is available to all parties interested in this market: we thank them for their generosity. We all look forward to welcoming new players into the sector, lured by the prospect of a significant, growing business."

Offshore wind in the UK is rapidly becoming one of the most exciting sectors in the global renewable energy industry.

Author:

BVGassociates

BVG Associates is a technical consultancy providing expertise in the design, implementation and economics of fuel-less renewable electricity generation systems.

The purpose of BVG Associates is to help establish fuel-less renewable electricity generation as major, responsible and cost-effective partner in a balanced global energy portfolio.

BVG Associates partners each have over 20 years of experience working in the wind energy sector, much gained working hands on within wind turbine manufacturers.

Bruce Valpy, a chartered, Cambridge-educated mechanical engineer, co-founded BVG Associates in 2005. He leads industry wide supply chain development activities on behalf of BERR and others as well as working for private clients on four continents. Bruce authored BWEA s Report *Offshore Wind: At a Crossroads*, published in April 2006.

Funding Partners:

DEPARTMENT FOR BUSINESS
ENTERPRISE & REGULATORY REFORM

BERR leads work to create the conditions for business success through competitive and flexible markets that create value for businesses, consumers and employees. It drives regulatory reform, and works across Government and with the regions to raise levels of UK productivity.

Envirolink Northwest

Envirolink Northwest is an industry led, not-for-profit organisation representing the environmental technologies and services (ETS) sector in England s Northwest.

Our aim is to improve the productivity and competitiveness of the Northwest ETS sector and to enable Northwest organisations to exploit current and future business opportunities.

Our vision is to make the ETS sector in England s Northwest into a world leader in turning new ideas and emerging technologies into profitable businesses in the high growth markets for environmental technologies and services. Fulfilling this vision will create wealth and jobs while protecting and enhancing the environment cost-effectively.

We help Northwest ETS companies to find and win new business, we provide a forum for the exchange of information, knowledge and expertise; we stimulate the formation of partnerships and consortia to address market opportunities and provide a sector focus for the NWDA and other regional and national bodies.

offshore marine management

Offshore Marine is proud to support this report and continues to support the industry by re-investing in the Offshore Windfarm Industry.

Offshore Marine is an independent provider and supplier of managed marine solutions to the Offshore Renewable, Subsea Telecoms and Oil and Gas industries for our clients both nationally and internationally. Offshore marine specialises in subsea cables and accessory procurement, subsea offshore consultancy, cable protection solutions, offshore project support, cable remedial works and supply of experienced personnel and vessels. Offshore Marine is committed to providing a total marine service and solutions. Based in Bristol, our offices service the UK and European Sectors.

RENEWABLES EAST

Renewables East is the renewable energy agency for the six counties of the East of England.

Providing strategic business advice to and on behalf of the East of England and East Midlands Development Agencies, Renewables East exists to drive forward the development and deployment of low carbon energy solutions into the regional economy, generating jobs and economic benefit in doing so.

Through a growing team of commercially-minded, business focussed individuals, Renewables East seeks to identify regional and national market failures within the low-carbon agenda, and will invest £1.2M of public sector funding during financial year 2007/8 to address such failures.

Due to open in summer 2008,OrbisEnergy is set to become home to businesses representing the entire offshore renewables value chain from development, to operation and maintenance services. With panoramic views across the southern North Sea, OrbisEnergy will also provide prestigious Conference and Exhibition facilities for up to 220 people, including state-of-the-art ICT systems.

A report prepared for BWEA by BVG Associates Winter 2007

UK Offshore Wind: Moving up a gear

An updated assessment of UK offshore wind deliverability to 2015 and beyond

1 INTRODUCTION

A 'RIGHT TURN' AT THE CROSSROADS

Background

BWEA and Renewables East jointly published the report *Offshore Wind: At a Crossroads* in April 2006, in advance of the UK Government's 2006 Energy Review. This was at a time of political uncertainty regarding the future support for offshore wind in the UK.

The dawning realisation of the technical difficulties, rising cost estimates and potential supply chain limitations for offshore wind contributed to this uncertainty. It was clear then that there was an immediate-term economic gap which needed to be filled if the industry was to have a chance to deliver, but no certainty that it would then actually be able to deliver if the gap was filled – hence the feeling at the time that the industry was 'at a crossroads'.

The future direction of the offshore wind industry depended to a large extent on Government policy. One direction for the Government to take 'at the crossroads' was a **continuation of current policies** (meaning no additional support); another direction was a **new policy impetus in 2006** (leading to an economic environment sufficient for 'good' projects to be developed).

The last report addressed in detail the ability of the industry physically to deliver sufficient installed projects and concluded that if the economic environment was changed, it could indeed deliver significant capacity towards the UK's 2015 renewable energy targets.

In May 2007 the Government published its Energy White Paper in which it appears to have taken the 'right' turn at the crossroads, as far as the offshore wind industry is concerned.

> *"All in all, the Energy White Paper has enabled investment decisions to be made that would not have been made.*
>
> *The request to finance our project could not even have been taken to the board at 1 ROC/MWh."* OFFSHORE DEVELOPER

This report

With the publication of the Energy White Paper in May 2007, the time appeared ripe to repeat the At a Crossroads process, to test whether the decision to band the Renewables Obligation, with offshore wind receiving 1.5ROC/MWh, provided the policy impetus required to maximise offshore delivery. It also appeared appropriate to return to the supply chain in order to re-evaluate its ability to deliver the capacity forecast by developers.

The purpose of the process and report is to:

Listen to the industry then inform BWEA, Government and the industry generally about the current status and forward plans of the offshore wind sector.

Summarise key challenges and opportunities facing developers and the supply chain.

Promote supply chain investment by presenting data showing the opportunities.

Help increase the understanding and flow of information between relevant parties.

Help position the UK offshore wind market within the European offshore wind market.

Summary of findings

A headline summary is provided below, followed by key findings relating to each section of the report. The arrows signify direction of any change since the last report.

ECONOMICS

ROC multiple increase partly offset by rising supply chain prices.

SITE AWARDS

Progressing towards new awards in 2010 after a six-year gap.

CONSENTING

Good dialogue with stakeholders about improving processes.

GRID

Offshore frameworks being put in place. Onshore limits may affect.

SUPPLY CHAIN

Constraints remain, but appetite for investment growing.

OPERATION

Reliability concerns remain. Technology can improve.

Energy White Paper

Section 3 reports the various views and opinions of the offshore wind farm development community and supply chain to the UK Government consultation and resulting policy statements.

Overall

The Energy White Paper is welcomed and the increased ROC multiple for offshore wind is recognised as improving the economics of offshore wind farms.

Developers are seeing ongoing supply chain price increases that materially offset the benefits announced in the White Paper. Developers seek further rapid progress in key enabling areas of consenting and grid connection in order for development not to be held up.

UK installation forecast

Section 4 of this report contains a repeat analysis from *Offshore Wind: At a Crossroads*, this time carried out after the publication of the Energy White Paper in May 2007, deriving a revised forecast of UK offshore wind installation activity to 2015.

It forecasts the installation of 6.6GW offshore wind capacity in the UK by 2015 (prior to any adjustment due to supply chain limitations – see Section 6), corresponding to around 40% of the Renewables Obligation for 2015/16.

Section 4 then presents a comparison of the revised forecast with forecasts from April 2006 and August 2006. The comparisons show that:

The Energy White Paper indeed gives significant policy impetus to offshore wind, broadly in line with what was forecast under the scenario new policy impetus in 2006.

For the first time in the offshore sector, there is no trend of significant slippage in implementation plans in recent times. The dominant attitude of the sector is to progress projects as fast as reasonable.

Supply chain capability and impact on Installation plans

Section 5 considers supply chain capacity in the light of the forecast from Section 4, reflecting on changes within the last 18 months. It incorporates latest forecasts of EU-wide and global offshore activity.

The main limitation is expected to be wind turbine supply, but installation vessel shortages may also impact projects' costs.

Investment to meet future demand is starting to increase.

Section 6 summarises the impact of any supply chain limitations.

Limitations are forecast to slow installations in the period 2010-13, causing an overall decrease in installation activity of 200-300MW up to 2015. This is less than 5% of cumulative installed capacity to 2015.

Future site awards

Section 7 discusses proposed future UK offshore site awards, giving developer feedback on the timing and process for future awards:

Developers are keen to engage with all stakeholders in order to shape effective processes for site awards and consenting, so that the industry can accelerate delivery of renewable energy generation targets.

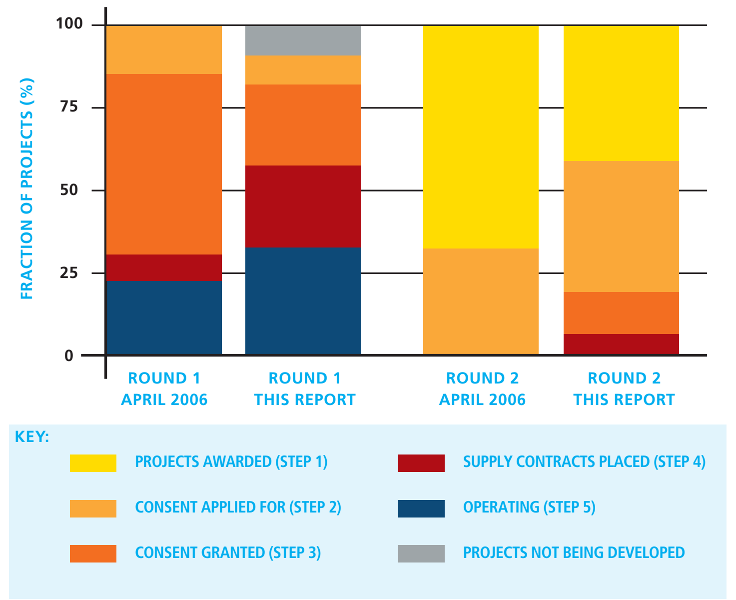
The sector wants increased accountability for themselves and consultees in the planning process.

Conclusions

Section 8 provides conclusions, incorporating an overall forecast of UK offshore activity to 2015.

With progress in various enabling activities, the UK offshore market is well positioned to deliver around 6GW of offshore wind capacity by 2015, thus providing the largest contribution by far to renewable energy generation in the UK by then.

UK Offshore Wind Project Status GRAPH 1



"UK Government has done some pretty good work."
DONG ENERGY

"Now with banding, UK is the market where things will happen, even with price rises."
VESTAS

"It is essentially becoming a competition of national subsidies for limited supply... Government had to make offshore wind work to meet targets."
UTILITY DEVELOPER

2 OFFSHORE WIND TO DATE

The first offshore wind project was installed in 1991 in Denmark. By the end of 2007 more than 1,100MW of offshore wind will be in operation globally, almost all in Europe.

Currently, the UK's fifth offshore Round 1 project, Burbo Bank (90MW), is in commissioning, and offshore construction work has started on three other sites. These are Robin Rigg (180MW), Rhyl Flats (90MW) and Lynn and Inner Dowsing (194MW) which, when completed, will become the world's most powerful offshore wind farm. Also, the deeper-water Beatrice demonstration project (10MW) will reach full operation this year. In the last 18 months, two Round 1 and three Round 2 consents have been granted and four further consents have been applied for. Also, the first significant firm supply contracts for a Round 2 project have been placed.

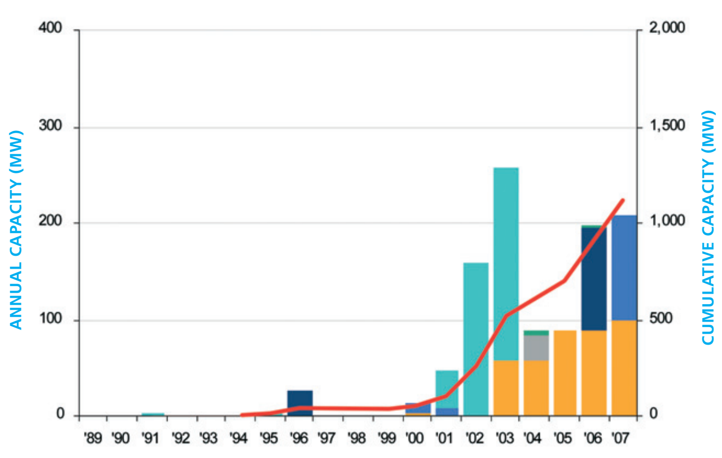
It is now clear that 2008 will be the busiest year so far, by far, for the offshore wind sector, and will result in the UK taking over top spot in the global offshore wind market – the current UK capacity was installed steadily over the last five years; it will be more than doubled within two years.

Graph 1 summarises the status of projects against key milestones. It shows significant progress of both Round 1 and Round 2 projects since April 2006, in addition to those Round 1 projects that have come on line. Note that larger Round 1 projects such as Robin Rigg, made up of a number of (initially) 30 turbine projects, are counted here as single projects.

Outside the UK, Lillgrund (110MW), off Sweden, will be completed in 2007, and Q7 (120MW), off the Dutch coast, will be all-but commissioned. Contracts have this year been placed for pilot projects in Belgium, France and Germany.

The global growth of offshore wind capacity to date is presented in Graph 2. Forecasts of future activity are presented in later sections.

Global Offshore Wind Capacity to Date GRAPH 2



BY END	1995	2000	2005	2007
GW OPERATING GLOBALLY	0.01	0.04	0.7	1.1 (EST)

KEY:

UK
DENMARK
SWEDEN
NETHERLANDS
GERMANY
OTHER (IRELAND, JAPAN)
CUMULATIVE GLOBAL CAPACITY

3 WIND INDUSTRY COMMENTS ON THE ENERGY WHITE PAPER AND ASSOCIATED ACTIVITIES

This section summarises comments received on the Energy White Paper, and related documents and activities. The input was also used to inform BWEA's response to the consultation on the Renewables Obligation reform.

On the Energy White Paper generally

Both the overall thrust and details have generally been well received. Many developers had already factored in anticipated changes to their financial calculations, so the White Paper has given some level of policy continuity, rather than a significant jolt. There is a firm underlying assumption that in the current political environment the proposals contained within the White Paper will become law in a timely manner and without challenge.

It was noted by many that the White Paper contains no definitive statement regarding converting 2020 aspirations into firm targets. It is recognised that this most likely reflects the Government wish to negotiate and then plan delivery of the UK's share of the EU 2020 renewable energy targets in due course before introducing changes. It is generally anticipated that EU targets will drive an increase to the current Renewables Obligation levels.

The following is a collated response from all developers who provided an answer to the question "How does the Energy White Paper affect your company's attitude to investing in the offshore wind sector?":

"At full blast, anyway."

"Had taken the decision some while ago that offshore wind was here to stay – the policy has reinforced this decision."

"Positive outcome on investment for offshore wind."

"The Energy White Paper reinforced the view that the UK is one of the most attractive offshore wind markets."

"All in all, the Energy White Paper has enabled investment decisions to be made that would not have been made. The request to finance our project could not even have been taken to the board at 1 ROC/MWh."

"It helps."

"Very good for the industry."

"Not impacted – confirmed what we hoped and given more confidence."

"Steps in the right direction. Very good start. Reasonably content."

"Won't accelerate activity much. Was at full speed on upcoming projects anyway. Helped by moving up the gears on future projects."

Further comments, both positive and negative, on specific aspects of the White Paper are presented in the sub-sections below.

> *"It is essentially becoming a competition of national subsidies for limited supply… Government had to make offshore wind work to meet targets"*
>
> *UTILITY DEVELOPER*

On the Renewables Obligation

Relative continuity in not abandoning the RO was welcomed, though the expectation of future reviews of the ROC multiples and uncertainties regarding the size of future project awards do reduce investor certainty compared to feed-in solutions.

A number of developers pointed out that no change to the ROC horizon past 2027 will have a significant impact on projects coming online in 2014 and beyond. It is expected that post 2027 considerations will be addressed at the same time as responding to the 2020 EU renewable energy targets.

For some, co-firing remains an unwelcome uncertainty factor, with a different set of drivers from fuel-less renewables but with the capability to produce a significant number of ROCs. The view is that this uncertainty may decrease the efficiency of the Renewables Obligation. Others believe that co-firing is likely to compete only with other fuel technologies.

Some developers raised concerns about the headroom mechanism, arguing that 6% is insufficient and that (up to) 10% is required. No specific feedback was received on grandfathering.

On changes to the ROC multiples

The increase in offshore wind ROC multiple, coupled with continuity in the onshore wind ROC multiple, has been accepted positively, though many advise that the improvement in offshore project economics is not as significant as might be expected.

"Pretty positive, by and large – what we asked for – did we ask for enough?" FARM ENERGY

"Helped, but only maintained status quo against rising costs." UTILITY DEVELOPER

For all who expressed a view, the increased ROC multiple of 1.5 for offshore wind was higher than anticipated. A number expected a lower multiple but for an extended obligation period, having a similar overall effect on project economics. Some see the higher multiple as helping to promote the UK offshore wind market above other EU markets. A number of developers expect other EU governments to compete with the UK in terms of market attractiveness, especially in the light of upcoming EU 2020 renewable energy targets. Indeed, since the Energy White Paper, the German Government has announced proposals to increase the initial feed-in tariff for electricity generated by offshore wind farms by between 25 and 60%.

"Project economics sensible – this will never be a business that will spin gold – but one can make a reasonable return. Economics may kill off one or two of our projects…" DONG ENERGY

Though the multiple is higher than generally expected, most developers advised significant supply chain cost increases within the last 18 months, partly in response to the increased revenue available from offshore wind projects due to the changes announced in the Energy White Paper. These increases in some cases take up all the benefit of the increased ROC multiple. A number advised that the increases were 'across the board', reflecting a sellers' market in a number of key supply areas, not solely specific to the wind industry.

A number of developers recognised that there would be some negative impact on onshore wind, even with the ROC multiple preserved. This is due to the increased delivery of ROCs from offshore wind, but there was a general acceptance that the impact would be delayed and that it was acceptable. Note that onshore-only developers were not consulted in this study.

It was also noted that (say) a 15% renewable generation target and 15% ROCs target are inconsistent when working with multiple ROCs. Clarity on the implications of the separation of ROCs and MWh is requested.

On planning

A common thread running through developer responses was that although the Energy White Paper offers a route forward regarding economics, a major problem continues to be timescales and uncertainties relating to planning consent for both offshore and onshore aspects of projects.

Repeated concerns were raised covering areas such as the negative impact on the sector due to the stop-go-effect of consenting, the perceived inconsistency between Government policy and the consenting process and inconsistent/over-application of the precautionary principle by statutory consultees. The Planning White Paper is seen as a small step in the right direction, but a process requiring more structure and stakeholder accountability was requested. Concern also was raised at the perceived low priority given by Gordon Brown to the Marine Bill.

On the associated consultation

Government openness and willingness to hold substantive consultation generally was recognised and welcomed by developers.

"Clearly some responsiveness from Government… In fairness they have listened…" UTILITY DEVELOPER

On the Ernst and Young Report Impact of Banding on the Renewables Obligation – Costs of Electricity Production

BERR based its derivation of the ROC multiples proposed in the Energy White Paper partly on analysis commissioned from Ernst and Young, published alongside the White Paper.

Developer response to this analysis was as follows:

"Good piece of work – on the right page" FARM ENERGY

"CAPEX looks low – £1.8m/MW is our baseline." OFFSHORE DEVELOPER

In general, developers agreed with the analysis conducted, with the following caveats:

CAPEX estimates now are too low. Recent CAPEX increases partly are in response to the increased ROC multiple. In a 'sellers' market' for wind turbines, this, however, could have been anticipated. The CAPEX for Rhyl Flats was recently announced at over £2m/MW, for example.

The analysis seems a bit simplistic, not reflecting realities of EU offshore and global onshore competition.

No cost reduction due to learning is shown post 2015. It is anticipated that significant progress will be made as installation of projects post Round 2 commence.

On grid and offshore transmission arrangements

Overall, there was little response regarding grid issues. This reflects the focus of the interviewees rather than the relevance of the subject.

A number of developers flagged the lack of suitable onshore grid connection points as a significant potential bottleneck requiring high-level intervention.

Locational pricing is seen as having an unfair impact by some, skewing the market unhelpfully towards sites with lower wind speeds.

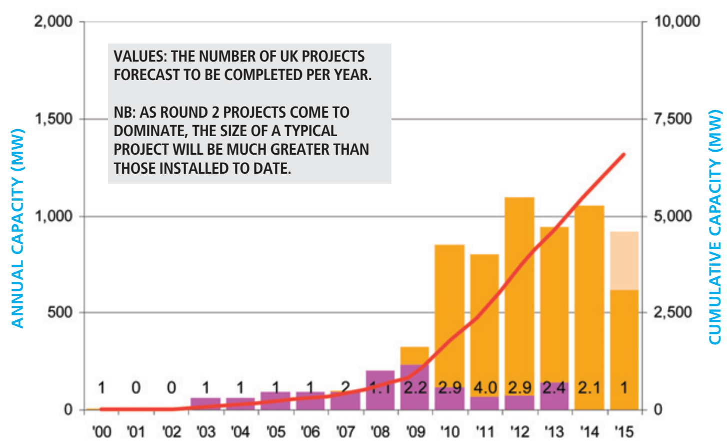
Many developers have provided full responses to the Ofgem/BERR joint policy statement published in July. Overall, these responses include concerns regarding the complexity of the arrangements, with likely knock-on consequences in terms of project delays and costs. A key concern relates to the time required for a possible annual competitive tender process for transmission system suppliers that will only start after a developer submits a connection application.

4 INSTALLATION FORECAST

The aggregate forecast in Graph 3 is based on developer input received between June and August 2007. It does not include the possible effect of supply chain limitations other than that built into individual project plans by each developer. These limitations are discussed in Section 5 and the implications presented in Section 6.

This middle-road forecast is based on the industry response to the UK Government Energy White Paper and other prevailing conditions. It is derived by aggregating time plans provided by the developer for each UK project and takes into account both the probability of a given project being constructed (due to constraints imposed by

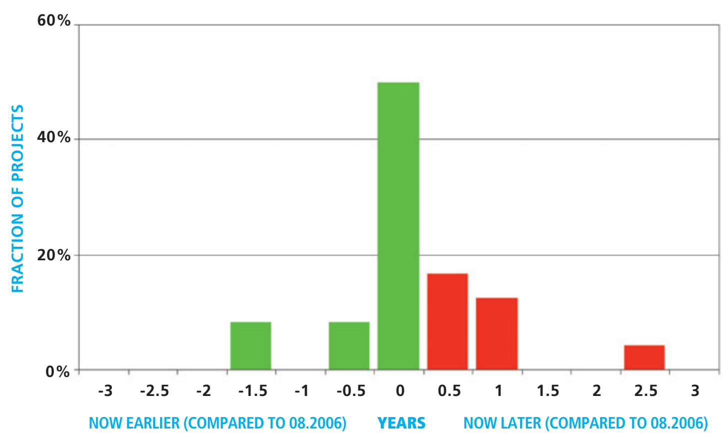
UK Offshore Wind Capacity GRAPH 3
WITH NO SUPPLY CHAIN LIMITS IMPOSED



BY END	2000	2005	2010	2015
GW OPERATING IN UK	0.0	0.02	1.8	6.6

KEY:
- UK OFFSHORE ROUND 1 PROJECTS
- UK OFFSHORE FUTURE ROUNDS (INDICATIVE)
- UK OFFSHORE ROUND 2 AND OTHER KNOWN PROJECTS. ROUND 2 ACTIVITY FORECAST TO CONTINUE UNTIL 2019
- CUMULATIVE CAPACITY

Changes in Planned Installation Date for Projects GRAPH 4
COMPARED TO AUGUST 2006



consenting, economics etc.) and the chance of delivering 'on time'. A detailed description of the methodology used to derive the forecast is provided in Appendix A.

In general, the mood of developers of UK offshore sites is more upbeat than 18 months ago. A number of utility developer players are in the process of restructuring to create pan-European (or global) renewables divisions, with an associated change of perspective regarding offshore wind from 'obligation' to 'opportunity'.

"Our strategy is to obtain significant value from our renewables business in delivering UK and pan-European targets"
UTILITY DEVELOPER

The same can be said for a number of supply chain players.

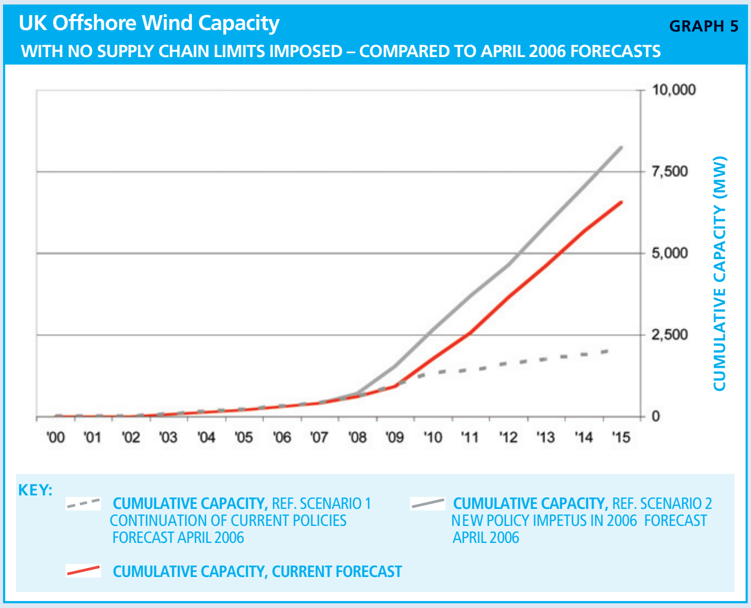
In comparison to developer expectations gathered using the same process in August 2006 (i.e. after publication of the Energy Review), Graph 4 shows that there has been little net change in anticipated installation date for UK offshore projects over the last year, unlike previous predictions which have shown significant slippage each time. For example, in the six-month period to August 2006, the same analysis showed an average eight-month slippage.

Note that all projects are given the same weighting independent of size, year of anticipated completion and probability of completion.

Having said this, it is recognised that economic, supply chain, planning and grid concerns remain firmly on the horizon in front of developers of UK offshore wind projects.

Graph 5 compares the current forecast with those from April 2006. By 2015, the current forecast is three-quarters of the way from *At a Crossroads'* Scenario 1 (economic gap remains) to Scenario 2 (economic gap closed for good projects), suggesting that the policy initiative proposed indeed closes a significant portion of the economic gap. It can be seen that up to 2009, however, the current forecast tracks Scenario 1 – economics unchanged. This demonstrates the time that it takes for the policy initiative to actually have an effect, partly due to the length of the legislative process.

"We increased the expected growth rate for the total market (on- plus offshore) until 2011/12 significantly when compared to what we believed last year" SIEMENS WIND POWER



5 SUPPLY CHAIN CAPABILITY

The question of what the wind industry can physically deliver cannot be addressed for the UK offshore wind industry in isolation. In this report, the capacity of key supply chain elements to deliver is examined in the context of the project time plans from developers of UK offshore projects, coupled with forecasts for other offshore wind markets, as presented in Graph 6. The method of forecasting non-UK projects is detailed in Appendix A.

By 2015 the UK will have a dominant share in the EU market, as illustrated in Graph 7. Note that the relative size of the charts reflects the relative cumulative installation capacities.

"For installations in 2011, we see the UK as around 50% of the offshore market, Germany as around 25% and the rest as 25%."

SIEMENS WIND POWER

Wind turbines

"Battle for turbines – so few players."

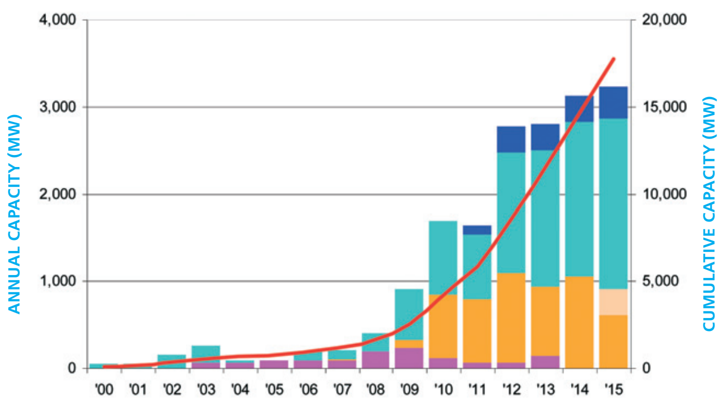
NORSK HYDRO

"Offshore wind customers are intensifying their efforts to secure supplies for their projects well in advance of actual implementation. Knowing the projects and the customers' thoughts and intentions at an early date gives better possibilities for successful projects. Customers are now realising that they have to commit years in advance with no possibilities of last minute shopping."

SIEMENS WIND POWER

Wind turbine supply remains a critical path item for most developers and the one least within the UK sphere of influence, as currently no wind turbine suppliers are headquartered in the UK and no offshore wind turbines are assembled in the UK. Lead times for turbines are up to 2-3 years and the offshore sector continues to be squeezed by the significant success of the global onshore wind market in response to

Global Offshore Wind Capacity GRAPH 6
WITH NO SUPPLY CHAIN LIMITS IMPOSED



BY END	2000	2005	2010	2015
GW OPERATING GLOBALLY (NO SUPPLY CHAIN LIMITS IMPOSED)	0.0	0.7	4.2	17.7

KEY:
- UK OFFSHORE ROUND 1 PROJECTS
- UK OFFSHORE ROUND 2 AND OTHER KNOWN PROJECTS
- UK OFFSHORE FUTURE ROUNDS (INDICATIVE)
- EU NON-UK OFFSHORE PROJECTS, PLANNED AND FORECAST
- NON-EU OFFSHORE PROJECTS, PLANNED AND FORECAST
- CUMULATIVE GLOBAL OFFSHORE (INC. UK)

the rapidly growing need for sustainably produced, low-carbon energy.

Today, only two turbine suppliers, **Siemens Wind Power** and **Vestas**, have built a credible offshore pedigree. Currently, **Vestas** (global wind turbine sales ranking in 2006 #1; Danish) has placed a moratorium on the supply of its offshore product, the V90-3MW, until a solution to recent gearbox problems experienced on a number of offshore wind farms has been tested. **Siemens Wind Power** (ranking #5; Danish) has two products, rated at 2.3MW and 3.6MW. With so little choice, in the short term the turbine market is quite distorted and not functioning as a competitive system. However, the situation is changing. **REpower** (ranking #7; German), majority owned by Indian **Suzlon**, has recently installed its first offshore turbines, rated at 5MW (soon to be increased to 6MW). In addition, **Multibrid** (minimal sales; German) in which French firm **Areva** recently bought a majority stake, is set to install its first turbines offshore in 2008, also rated at 5MW.

"Market forces – we expect more entrants offshore within the next five years. Extra global capacity will provide the necessary hunger."
DONG ENERGY

Splitting entry into three pools of wind turbine suppliers up to 2015, the following players are anticipated to have this pedigree in due course:

POOL 1
(pedigree established now):
Siemens Wind Power and Vestas.

"In the next three years, our offshore capability will be minimum one project per year in UK. Each project could be between 100 and 500MW." VESTAS

"In the next three years, our global offshore capability will be around three large projects per year."
SIEMENS WIND POWER

POOL 2
(pedigree established by end 2011, latest):
REpower and Multibrid.

POOL 3
(pedigree established by end 2015, latest):
Three suppliers from a pool of seven including (at least) new players DarwinD, Bard and Clipper Windpower and existing big players GE Wind Energy, Gamesa, Enercon and Nordex.

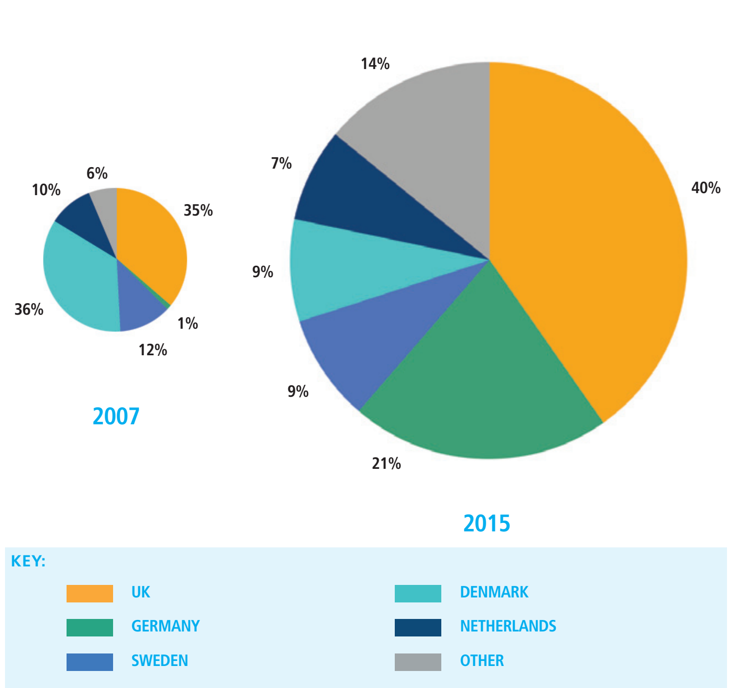
Supply forecasts are limited by different factors for different turbine suppliers, including combinations of:

Offshore pedigree and financial strength *(as viewed by customers).*

Management of risk *(as viewed by wind turbine supplier).*

Availability of contracts with suitable terms *(compared to onshore opportunities).*

EU Offshore Wind Capacity at the end of 2007 and 2015
WITH NO SUPPLY CHAIN LIMITS IMPOSED GRAPH 7



Component supply availability.

In the period 2010 to 2013, the aggregate developer forecast exceeds the aggregate wind turbine supplier forecast for two out of the four years. Due to the barriers to market entry and acceleration of sales, turbine limitations are viewed as a 'hard' limit – it is likely that the situation could be changed only with very significant intervention.

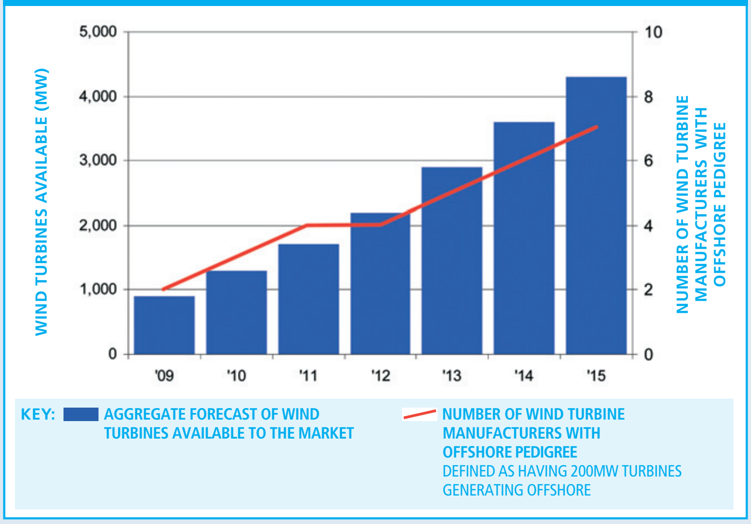
Looking further ahead, in response to global onshore wind demand, a significant number of new entrants are developing onshore technology in order to enter the market. Many of these players are located in growing markets which are also low-cost manufacturing locations. Their entry is likely to squeeze established European turbine suppliers at the same time as the European offshore wind sector grows from providing a negligible (though high risk) contribution to total wind turbine sales to providing a significant fraction, as shown in Graph 9. Onshore historical data is taken from Wind Power Monthly; forecast from Make Consulting.

It is anticipated, therefore, that there will be a growing readiness for European wind turbine suppliers to service the 'home' Europe-dominated offshore sector, where their advanced technology and experience can best be used to mitigate severe operating environments. The offshore sector is likely to become the driver for the commercialisation of cutting edge technology and best practice which in time will flow out to the rest of the wind industry.

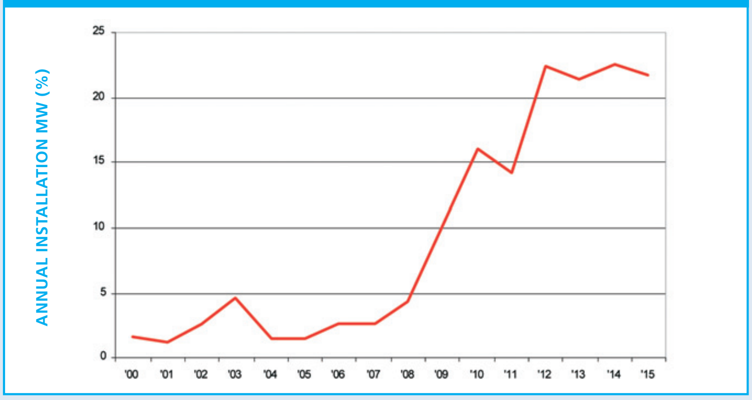
As an example of the growth in focus on offshore by the wind turbine suppliers, Vestas Offshore now employs around 270 people, around five times as many as 18 months ago. Other evidence is Clipper Windpower's recent announcement regarding design of a very large offshore turbine and the use of the North East UK port of Blyth as a centre for its European offshore wind activities.

"EU turbine manufacturers will be dependent on offshore wind. If they want a stable market, then they need to enable it. Expect manufacturers in low-cost markets to take a lot of business onshore, with high quality turbines being used offshore. This transition will take quite a few years." DONG ENERGY

Wind Turbines Available for the Global Offshore Market Capacity *and* Number of Wind Turbine Manufacturers with Offshore Pedigree GRAPH 8



EU Offshore Wind Installation as % of EU Total Wind Installation GRAPH 9



"Offshore is clearly a focus area. I see Siemens as the leader with a vision to keep it that way. Volume-wise, onshore will be the biggest chunk but offshore does give an opportunity for differentiation." SIEMENS WIND POWER

"Today we prefer to supply, install, test and commission the wind turbines and the SCADA system. In time (years) we hope to move back up the value chain (incrementally)." WIND TURBINE SUPPLIER

Wind turbine component bottlenecks remain gearboxes (including associated bearings and high quality steels), large castings and forgings. It has been argued that per MW of delivered capacity, larger offshore wind turbines use more supply chain resource than onshore turbines, hence their manufacture is 'inefficient' in the broadest sense. At least one supplier rejected this argument. It is noted that with offshore wind holding a segment share of 15-20% of EU turbine installations, physically being able to supply turbines to the offshore market is not likely to be the limiting issue. More important is whether turbines of the desired size are made available by wind turbine suppliers at a cost and under terms that projects can bear.

The rate of growth of turbine size (MW) entering the market continues to slow. Existing suppliers of offshore turbines generally expect that variants of today's turbines will remain core products dominating sales into 2012/13, with next-generation, larger technology only taking over as we head towards 2015. This vision matches reasonably with the expectations of developers (see Appendix C). To counterbalance the lack of availability of large turbines conceptually designed for the offshore market, it is anticipated that during the next years, reliability of existing machines will indeed reach the levels required in order to bring the service costs for offshore wind farms down to acceptable levels.

"Expect that in 2011, close to all of our offshore sales will be of existing models, rather than new products." WIND TURBINE SUPPLIER

In recent years, offshore wind farms have suffered higher than expected loss of generation, with the main drivers including:

Gearbox failures *(especially bearings).*

Generator failures *(and associated cable connections).*

Subsea cable damage.

Operator access limitations.

It is vital to the sector that reliability is improved, with R&D priorities set in order to minimise lifetime cost. In some cases, the balance may be to increase capital expenditure to reduce operational expenditure.

"A main driver for removing turbine bottlenecks is long-term, consistent high availability of offshore wind farms. People on all sides are 'spooked' by experiences of unreliability." DONG ENERGY

Wind turbine installation vessels

The improvement in funding arrangements and the other support measures announced in the Energy White Paper have produced a positive reaction and an increase in activity by offshore wind farm developers. Vessel operators all report that this trickle down of improving market confidence commenced "4 to 6 months ago" but to date it has not been strong enough to change the minds of board room members and investors into commencing speculative construction and/or long term charter of suitable vessels for future business.

Part of the reason for the cool reaction of the vessel supply chain compared to that of developers is that 'positive messages' of a boom in the industry have come and gone before. Speculative investments made by installation contractors to meet earlier perceived demand have led a number towards financial losses. Now vessel owners want firm commitments to back up further investments in new vessels and services.

Typical lead times from date of investment decision for a new vessel to enter the market have been given as nine months for modification of an existing vessel, to up to three years for a new build of a 'typical' jack up barge/self propelled installation vessel.

An eventual shortage of installation vessels has been predicted by many for some time – it can be argued that this is precisely to be expected at some point in a young market-driven industry. ODE's Offshore Wind Farm Installation Vessel Capability Study for BERR in Spring 2006 predicted a significant shortage of vessels starting in 2008, building to a peak shortfall of installation vessels in 2012. Although the ODE analysis was based upon a project delivery forecast which is quite different from the forecast presented above, nevertheless it appears to reflect the current tight situation.

"There is a short term shortfall now, and next year (2008) demand will outstrip supply" VESSEL OWNER

"Installation vessels absolutely are the supply chain limit before turbines." VESTAS

"Hell of a fight for vessels." NORSK HYDRO

To balance this viewpoint, some developers and vessel owners advise that there are plenty of vessels that could be used, and new ones can and will be built if necessary; the position is that up to now project developers have not needed to make the necessary commitments to ensure their availability for specific builds. One exception has been Centrica's long-term charter of the Resolution.

"If we really had faith that the offshore wind market was there, we would make the necessary resources available." VESSEL OWNER

"A new vessel could be ready in less than a year if the demand was serious." VESSEL OWNER

In the short term, there does seem to be a shortage of specialist vessels and contractors who have experience in the offshore wind industry and who have the incentive to innovate to reduce costs down to levels that enable reasonable project returns. The contractors who have experience of wind turbine installations are already reporting full order books to beyond 2010. Taking only the capacity of existing installation vessels and contractors with experience in the wind sector, the installation capacity constraint is of the order of 400-1,000MW/year.

The expectation is that without innovative activity, vessel availability may limit installation in around 2010, though the degree of limitation is hard to define. Part of the reason for this is that even with a known pipeline of projects with vessels lined up to install them, the variability of weather (wind and wave conditions) even in summer can significantly affect the efficiency of rate of installation by vessels. For example, the 25 topsides at Burbo Bank were installed in only 43 days during 2007, a rate of more than 2MW per day, whilst other wind farms have been held up significantly at a similar stage, with work taking a number of times longer.

Another uncertainty that has impacted recently is that with a small pool of specialist vessels, technical problems on one project or vessel can have significant knock-on effects. For example, at the end of July the crane boom on installation vessel Sea Jack (formerly the Jumping Jack) collapsed, and since then, a leg of the Lisa A sank into the seabed at Robin Rigg during foundation installation work, prompting an emergency crew evacuation. Each has caused delays in already tight installation programmes, with knock-on effects on subsequent projects.

Accepting these uncertainties, it is suggested that installation vessel shortage in the medium term is not a 'hard' limit to deliverability of offshore wind capacity in the same way as the current wind turbine supply situation, where the market conditions, supply chain situation and lead times for the development of new products are such that increased supply could be stimulated only with very significant intervention. Vessel shortage is a 'soft' limit – one that can be avoided on a project-by-project basis by planning ahead and use of non-optimum vessels, albeit with some financial pain. A subset of oil and gas vessels and methodologies are capable of filling short term needs for wind farm installation capacity, but oil and gas work is expected to continue in parallel to wind, so direct use of oil and gas resources cannot be a long term solution.

Put another way, within the lead times of turbine supply, money can buy the one-off activity of wind farm installation because vessels exist in the global marketplace which could be made available to do the job. This is in contrast to turbines where more money will not necessarily enable supply of turbines suitable for a minimum of 20 years of offshore operation.

Thus, though vessels are expected to continue to be a critical supply chain element, they are unlikely to become the most critical as long as developers, vessel owners and financiers are able to find an equitable balance of risk and reward in making new investments. It is advised, however, that due to the complexity in matching vessel capabilities with turbine and site requirements and the fact that no player has a complete overview, developers engage in very early dialogue with potential providers of installation solutions in order to maximise the cost-effective use of installation resource.

"Developers are not prepared to talk enough in advance – they think they can hire quickly by picking up the phone – like a taxi."
VESSEL OWNER

Innovation is clearly needed (and to some extent happening) in the area of installation of large turbines in deeper water. Examples include:

Adaptation of oil and gas methods, taking into consideration offshore wind requirements in terms of number of rapid repeat operations, vessel layout and pricing structure.

Use of self propelled feeder barges to supply an installation vessel permanently stationed at the site, thus reducing steaming time for the high-cost critical path vessel. This requires floating-to-fixed lifting operations with heave compensation systems to avoid damage.

Single lift operations where turbines are fully assembled and tested on land and installed in one large lift, in line with prototype operations at the Beatrice project (also the Merlin concept from Engineering Business and 'Place and Plug' from Subwind).

Development of deepwater jack-ups to avoid the use of large (and expensive) semi-sub/dynamic positioning vessels.

Extension of working conditions to minimise lost time due to weather and extend the working season.

UK Offshore Wind: Moving up a gear

Foundation installation vessels

Generally, the pool of vessels used for foundation installation is the same as that for turbine installation and the arguments discussed above relate similarly to the installation of ever-larger foundations in deeper water.

As monopiles increase in mass, many of the standard vessels will not be able to manoeuvre them. During installation of a number of sites, monopiles were floated to site then turned in the water. It is anticipated that this process will become more widespread in order to most efficiently use existing vessels for monopile installation.

Another related consideration is the provision of monopile installation equipment, specifically large diameter anvils (each designed for a specific diameter). Two main players, IHC and Menk, have provided tooling for most offshore wind monopile installation tasks to date, and new anvils will be required as larger monopiles are produced. Significant investment and lead time is required to produce these new anvils. Most developers understand that they need to secure the use of such tooling before monopiles are manufactured. One way to reduce the size of anvils required for some ground conditions is to use conical-topped monopiles, but this introduces additional monopile manufacturing complexity and cost.

The availability of heavy-lift vessels for the installation of concrete gravity base foundations has not been investigated.

Cable Installation vessels

The view from suppliers is that they can meet the expected near-term capacity requirements and although it will take significant investment, they can increase capacity fairly quickly to meet future requirements, and there is a willingness to do so within the right frameworks. With a global pool of more than 20 suitable vessels, cable installation is not expected by those deeply involved to present a bottleneck. Cable faults due to poor installation have, however, been a source of interruption of windfarm operation; hence use of experienced contractors quite likely offers significant advantages.

In addition to main vessels, some projects need additional specialist tooling depending on conditions. Though not investigated here, it may be that the availability of specially designed cable ploughs and remote operated underwater vehicles (ROVs) could delay activity on a small number of sites.

Offshore Substations

In the next five years it is anticipated that offshore wind will require only a few percent of the output from transformer manufacturers. There is significant amount of infrastructure investment being made by utilities globally, which is putting pressure on delivery lead times. The lead time for transformers, a key long-lead element of offshore substations, has increased from around 12 months up to around 30 months over the last year. Developers are advised to factor in significantly increased lead times for transformers and also to consider spares holdings carefully.

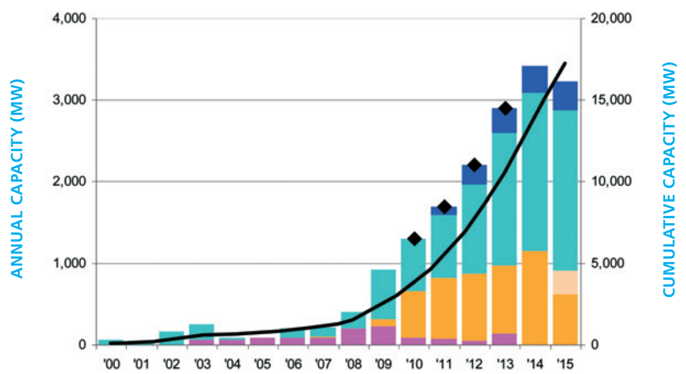
Transformer suppliers have plans to expand their capacity to meet anticipated future demand from a number of sectors, with a lead time of the order of three years from investment decision to first supply.

A forecast of UK offshore substation requirements based on aggregated estimates for each project is provided in Appendix C.

"Cable laying companies are also critical. They have gone belly up during the construction of just about every project... Hence valuable experience is lost as new companies are involved in each project. Consequently we see delays and rising cost. To assure staying power of these companies is crucial" WIND TURBINE SUPPLIER

Global Offshore Wind Capacity
WITH SUPPLY CHAIN LIMITS IMPOSED

GRAPH 10



BY END	2000	2005	2010	2015
GW OPERATING GLOBALLY	0.0	0.7	3.8	17.2

KEY:
- UK ROUND 1 PROJECTS
- UK OFFSHORE ROUND 2 AND OTHER KNOWN PROJECTS
- UK OFFSHORE FUTURE ROUNDS (INDICATIVE)
- EU NON-UK OFFSHORE PROJECTS, PLANNED AND FORECAST
- NON-EU OFFSHORE PROJECTS, PLANNED AND FORECAST
- HIGHLIGHT YEARS IN WHICH SUPPLY CHAIN LIMITATIONS ARE FORECAST TO REDUCE INSTALLATION RATES
- CUMULATIVE GLOBAL OFFSHORE (INC. UK) WITH SUPPLY CHAIN LIMITATIONS IMPOSED

"We do not see the offshore wind industry increasing at a rate that would challenge us."

TRANSFORMER SUPPLIER

"Cables – we know we have to wait and that costs have risen, but they are not really a bottleneck."

DONG ENERGY

Cables

One further supply chain concern raised by some developers is subsea cables. Two specific products make up the sector – medium voltage (MV), intra-turbine array cables (typically around 33kV) and high voltage (HV), offshore substation to shore cables, where relevant (typically 132kV+).

There is a consistent message coming from cable suppliers that the bottleneck is not strictly factory capacity but lead times. The lead times in HV cables has increased over the last year from about 12 months to 18-24 months due to the large demand from other sectors such as utility infrastructure, oil and gas.

Feedback from suppliers is that developers now are factoring in more realistic time-scales for subsea cable delivery. A number of suppliers see the future potential capacity requirements of offshore wind as well as other sectors and have firm plans to increase their capacity through investment in facilities. The delay from investment to first supply from new production lines is of the order of two years.

The view from the suppliers is that standardisation of cables across the industry would bring lead time and capacity benefits, as would the change from AC distribution systems to HVDC systems, as these dramatically reduce the amount of conductor material required. Evidence of this is that the first large order for an HVDC system to connect offshore wind farms has recently been placed with ABB.

A forecast of UK cable requirements derived from the sum of estimates for each project is provided in Appendix C.

"Much more activity than last year – more than we expected… Oil and gas work has slipped, which helps in us being able to deliver more for offshore wind."
MONOPILE SUPPLIER

"Currently putting in two new bays dedicated to monopiles up to 7.5m diameter… adding 10-20% more throughput." *MONOPILE SUPPLIER*

Foundations

Risk of limited supply of foundations remains of low concern to developers, though considerable interest remains in reducing the cost of foundations for larger turbines, in deeper water, by exploring alternatives to monopiles. In 2006, the Beatrice pilot project used a jacket-type structure in water depths of over 40m. In 2008, the first phase of the Thornton Bank project in Belgium will use a concrete gravity base design in water depths of around 20m for the first time. Simultaneously, the first phase of the Cote d'Albatre project in France will use a steel tripod design, in water depths of around 30m. All three projects use 5MW turbines. Other innovative designs including suction buckets have also been successfully trialled. One perceived advantage of alternative steel designs is the decreased requirement for piling equipment.

For the next 3-4 years, however, monopiles are likely to dominate supply. Though currently there are only 2-3 viable suppliers of mono-piles on the continent, these have combined capacity available for offshore wind monopile supply of around 1,200MW now, and together they have a reasonable growth or redirection capability that could be brought on line in less than a year. Together, for existing players the above capacity is roughly half their overall throughput.

New entrants (such as EEW in Rostock, Germany) are establishing, and other potential entrants exist if the market requires extra capacity. There is a fair chance that this extra capacity would be added in the UK. The likely limit to production is sufficient quality steel plate. An increased number of monopile suppliers is to some extent likely only to increase competition for the same steel plate. Currently, due to quality and certification issues, only a handful of European steel suppliers are used. In time and with the right enabling activity, other sources (including in China) will become available.

As new designs are demonstrated to be cost effective for different conditions, it is likely that the pool of foundation suppliers will grow. Overall, it is not anticipated that foundation supply with be a bottleneck.

UK Port Facilities

Though suitable port facilities in the UK are limited, there is no absolute necessity to use local marshalling facilities; thus, though lack of availability of ports may in some cases drive up costs, port facilities are not considered a bottleneck. Sufficient capacity is available in continental ports to meet future offshore wind demand.

The ports of Felixstowe, Lowestoft, Mostyn and Belfast are among those UK ports that have been used as a base for installation of offshore wind farms.

UK Offshore Wind: Moving up a gear

UK ports are seen as more expensive than most mainland European ports and generally suffer a lack of quality facilities and space available for the wind industry. Opportunities exist for changing this situation, but it is likely that investment will need to be made by local agencies, rather than expecting significant developer input. However, the returns on such investment could be considerable in terms both of direct work and gradual aggregation of associated businesses.

As an example of continental port activity, investment of €13m of public money has been budgeted for the development of offshore wind energy production facilities in the Luneort area of Bremerhaven on the North Sea coast of Germany. Facilities for the manufacture of blades and assembly of turbines are already in use by two wind turbine suppliers who have relocated capabilities to the site. Blade test arrangements and tower/foundation manufacturing facilities are planned to follow in 2008.

Close to the UK Round 2 Greater Wash and Thames Estuary strategic areas, development of the new East Port is underway at Great Yarmouth, but there is no evidence of anticipated significant use in the construction of offshore wind farms. Possibilities exist also for further development of Ramsgate, well located to serve upcoming Thames Estuary projects.

In the Northwest, the ports of Liverpool and Birkenhead are both accessible in all tides through locks and have adequate laydown space; Heysham also offers possibilities as a base for installation activities with suitable investment.

Elsewhere, other ports will have significant opportunity to capitalise on Round 2 and future rounds of offshore wind activity if early priority is given to provision of infrastructure required for offshore wind. Local ports are well placed to provide O&M facilities and initiatives are underway to develop these in a number of areas.

> *"Ramp-up also is limited by internal offshore project team growth"*
> *WIND TURBINE SUPPLIER*

People

Many developers are growing their teams in response to the general ramp-up in activity and the increased responsibility falling on developers, as multi-contracting becomes the current industry-standard approach. With the move to pan-European utility renewables groups, there is the possibility for UK to gain 'centre of excellence' status for offshore wind, but only with significant investment in bringing new staff on board.

In establishing significant teams with high competence, it is important to be able to provide a relatively smooth flow of work. One of the success criteria for future rounds of offshore wind site awards is that such a flow is established, from developers through statutory consultees to the supply chain. In a stop-go market, significant quality and risk issues can arise from the use of inexperienced or overstretched teams.

The sector is starting to recognise that in order to work effectively on offshore projects, significantly strengthened teams with new skills are required compared to the onshore wind sector. Many of these skills overlap with the oil and gas sector. This overlap increases as projects are developed further offshore, in more aggressive environments.

> *"We need external progress in the near future to justify continuation of the work programme and the costs of keeping the team operational (£1m/year)."*
> *OFFSHORE DEVELOPER*

In time, some expect that EPC contracts will return, but with experienced global infrastructure players taking on responsibility. Whichever model develops, a significant increase in skills is required. DONG Energy is seen as having aggregated a strong technical and practical team from the combination of development and consultancy divisions of its forerunner organisations. It is expected that others will follow that company's lead in terms of skills development.

Perhaps the greatest expansion required is in teams of offshore installation and service crews, where competition for staff is not simply with the North Sea oil and gas market (long-term decline projected) but with offshore industries globally (clear evidence of short and medium-term boom), where charge-out rates are frequently double those in wind and the workforce is highly mobile. As well as recruiting experienced offshore staff, the offshore wind sector will need to draw in resources from onshore activities; there will be a significant need for structured training processes against agreed minimum standards for staff making the transition from on- to offshore.

Innovation

A number of innovative R&D and commercial development activities are required to drive an increase in supply capability. Innovation is needed in a number of other key areas in order to increase safety and reduce lifetime cost, including:

Increased focus on H&S issues, following the tragic death of an onshore service crew member in the UK in 2007 and a serious injury during installation of the first offshore Beatrice turbine in 2006.

Further development of safe access and egress systems. For example, between 8 and 19 service days were lost each month in 2005 due to the inability to access turbines at the near-shore, UK East Coast Scroby Sands wind farm.

Establishment of offshore-located service bases where a number of wind farms are installed close together, reducing travel time for service operations.

Taking a fresh approach to wind farm technology where onshore top-end market constraints of noise, visual aesthetics and individual-turbine grid solutions are replaced by other demands such as ease of maintenance using lower-cost solutions and safe access. The challenge is that such large turbines, with increased tip speeds (and possibly only two blades, for example) are likely to be suited for offshore-only use, hence the risks and costs associated with product development and gaining a pedigree are increased and the potential market decreased, compared with today's multi-sector products such as the Vestas V90-3MW.

Creation of new offshore substructure designs for both shallow and deep water, holistically designed and analysed to optimise the cost and dynamics of the complete turbine and foundation system.

Development of new methods of onshore assembly, offshore installation, connection *and commissioning of very large turbines in deeper water.*

Progress with subsea cables, especially laying and maintenance techniques, and the potential use of connectors (wet or dry connect).

Exploration of new materials and advanced manufacturing techniques for blades and other components; also calculation methods and control strategies in order to reduce the use of commodities such as steel and copper in very large turbines.

Research into related enabling technologies such as energy storage (via flow batteries, compressed air energy storage etc.), energy demand control and forecasting, plus the use of hydrogen and other clean fuels as conduits for the storage and transport of energy.

Adopting a more strategic approach to lifetime cost reduction covering all aspects of wind farm supply and involving advanced load measurement, condition monitoring, remote diagnostics and risk-based inspection strategies in order to maximise the value of time spent carrying out service work offshore.

Further application of considerable oil and gas industry experience and innovation to offshore wind challenges.

UK opportunities and threats

Much of discussion above is relevant beyond the UK market. Currently with no home-based wind turbine suppliers and limited supply chain, the UK will need to have clear objectives and focus if it is to take full benefit of supply chain opportunities.

Opportunities include:

The UK has the best offshore wind resource in Europe and is expected to be the globally dominant market for offshore wind, long-term.

With the move to pan-European utility renewables groups, UK teams can gain 'centre of excellence' status for offshore wind within these groups, and hence be the main location for ongoing offshore wind activities.

The UK has a strong oil and gas sector, with many possibilities for cross-fertilisation of expertise to benefit the offshore wind sector.

The UK can develop significant energy export potential via international grid interconnections.

The UK can lead in the development of O&M good practice, with associated long-term service jobs, especially as turbines come out of supplier warranty periods.

The UK innovation community is well placed to develop technology focused on lifetime cost reduction of offshore wind energy.

The UK financial community is well placed to provide funds for investment in UK and other offshore wind projects.

Successes in offshore wind will provide knock-on benefits to the other marine renewables sectors.

The UK has the chance to cooperate with the other key active North Sea countries, Germany, Denmark and the Netherlands, based on each others' strengths, including development of inward investment opportunities.

Threats include:

Lack of control and deep understanding of key wind turbine technology due to continental ownership.

Possible turnaround of activity in oil and gas, squeezing UK marine engineering resources and diverting investment away from wind.

The UK manufacturing community having tough competition from experienced wind sector suppliers and low-cost entrants.

Only limited suitable port infrastructure is available now, thus restricting development of a range of shore-based implementation and support activities.

Conclusions

The dominant 'hard' supply chain limitation is wind turbines. Installation vessel availability is a significant issue but generally higher-cost solutions are likely to remain available, though these may price some projects out of the market. Overall, if there is confidence in long-term stable markets, investment in supply chain solutions will follow.

Key activities to increase critical supply chain capability include:

Ensuring active two-way communication between developers and the supply chain regarding key investment decisions.

Facilitating early involvement from the supply chain and commitment to it from developers on any given project and reducing barriers to supply chain relationships via use of processes such as FPAL and PILOT-type feedback.

Maximising pan-European investment through the creation of a number of solid

markets for offshore wind and grid interconnects to allow access to power buyers.

Providing innovation funding support in order to maximise the rate of learning, linked with wind industry feedback suggesting key priority areas and cross-discipline partnering to ensure end-user involvement throughout development activities. The industry also needs to take the opportunity to influence work plans at the new Energy Technologies Institute.

Providing access to market information needed to justify new business activity and facilitate business-to-business links within the whole of the EU offshore market, including with potential inward investment partners.

Keeping close watch on key potential supply issues such as installation vessels, and presenting the results of targeted supply chain reviews in order to ensure that necessary focus is given by the sector to address bottlenecks.

Growing a sufficient pool of skilled and experienced offshore staff in order to ensure quality installation and service work, vital for long-term reliability and integrity of offshore wind farms.

Appendix C presents selected data for the full range of EU projects installed or under consideration. It is intended that such data helps supply chain investment.

6 EFFECT OF SUPPLY CHAIN LIMITATIONS

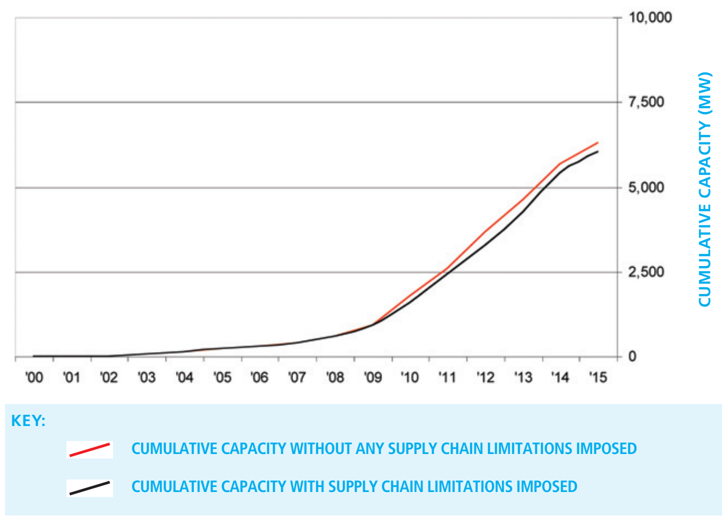
The quantitative effect of supply chain limitations discussed above is presented in Graph 10, using the forecast availability of wind turbines from Section 5 and following the methodology set out in Appendix A.

These limitations lead to a reduction in global offshore wind delivery in the years 2010-2013.

The cumulative installation forecast from Section 4 is shown in Graph 11, along with the forecast with supply chain limits imposed. This shows that the limitations have only a minor effect, causing an overall decrease in installation activity of 200-300MW up to 2015. The overall magnitude of the anticipated impact remains roughly the same as that forecast 18 months ago.

UK Offshore Wind Cumulative Capacity
WITHOUT– AND WITH SUPPLY CHAIN LIMITATIONS IMPOSED

GRAPH 11



7 FUTURE UK OFFSHORE WIND

SITE AWARDS

By the end of 2007, 25% of the anticipated 1.5GW of UK offshore Round 1 capacity will be operating but none of the anticipated 7.2GW from Round 2 will have been installed. Round 1 site awards were made in April 2001 and Round 2 awards were made at the end of 2003. It is likely that there will be a gap of around six years to the next awards, currently under discussion.

At least one player reported a switch in focus to Round 2 projects to the potential detriment of Round 1 projects. This reflects the industry's hunger for installed MW and relatively decreased workload per MW for larger projects.

Appendix B explores the anticipated build-out rates of typical future rounds and the impact of the timing and size of future site awards on the delivery of UK renewable energy to 2020.

In the following sub-sections, developer views on various aspects of future site awards are presented. There is openness from most developers to enter dialogue with BERR, Crown Estate and other stakeholders in order to shape effective processes for awarding and granting consents for future projects.

On UK targets

There is an appetite from many to invest in development activities for further offshore wind farms. Developers who expressed a view believe that a target of 20GW total installed capacity by 2020 is reasonable. The award of 30GW of sites by 2015 would ensure a suitable supply of projects to achieve this goal, as well as a pipeline of further work after 2020.

The aggregate of the expectations of individual developers of the size of their own portfolios by 2020 supports such a figure. It is recognised that this is above existing Government aspirations, but below likely needs in order to meet upcoming EU 2020 renewable energy targets.

On the timing of next awards

There is a general view that in order for the UK to even approach reasonable 2020 targets, significant awards will need to be granted at the latest by early 2010, with further awards following soon after in 2011 or 2012 and more beyond.

A number of developers are unhappy to wait until 2010, wanting options to develop sites before then. Such activity would also help smooth out the highs and lows in supply chain demand, and should therefore be thoroughly explored.

There is a hope that the impact of EU 2020 renewable energy targets will be to bring forward next awards, even if only within a small number of areas covered by existing Strategic Environmental Assessments.

"If Government holds up the process, then utilities should squeal if they can't build out to generate more ROCs and hence get fined for it." UTILITY DEVELOPER

On the size and rate of awards

Round 1 and Round 2 awards have not yet attracted UK manufacturing. Framework plans for future rounds should be announced in order to facilitate positive investment decisions by UK-based suppliers. In a competitive market between countries across Europe, an increased level of home capability may be critical in assuring delivery of targets.

A 'big bang' approach with 10s of GW of awards at one time is not welcomed by any party. Likewise, an ad-hoc process of developers knocking on Crown Estate's door with project proposals is not supported.

Instead, there is a wish for more frequent, smaller rounds of awards, avoiding the creation not only of humps in demand, but also in workload and resource requirement throughout the development and consenting processes.

On the award procedure and criteria

A robust procedure for allocating sites is wanted which must include demonstration of finance availability and credibility in taking the project through to construction. The process of re-awarding Westernmost Rough was deemed by most to be a step in the right direction.

The Danish model of government offering consented projects is not generally seen as more expeditious, with the general view that industry is better placed to decide where offshore wind farms should be built. However, suggestions were made about public/private cooperation to develop very large farms (e.g. Dogger Bank).

There is a wish for an open, free market with clear process and time rules. There is a wish to discourage prospecting, where some are paid premiums for access to sites just because they happened to stake a claim first.

> *"We would like to see awards based on the ability to deliver – we don't want prospectors. Our experience is that they significantly under-estimate costs."* NORSK HYDRO

There is openness from some to do pre-work before award in the same geographical areas as others, as long as the competition for awards is against robust criteria.

A process which allows one developer gradually to build a portfolio of projects located relatively close together would be welcomed, due to economies of scale and learning throughout the life cycle that can be established by working only in a single locality.

Overall, it is believed that a balanced range of developers should be encouraged, encompassing flexible small players (who can still 'go through with projects') and well-resourced utility players, maybe in JVs. The strengths of smaller, non-utility players are recognised.

There is a general wish for a process that avoids perceived problems with awards to date, including:

Negative impact of prospectors
(both large and small).

Issue of awards for some Round 2 projects in the Greater Wash that are located unacceptably.

On policing of the awarded sites

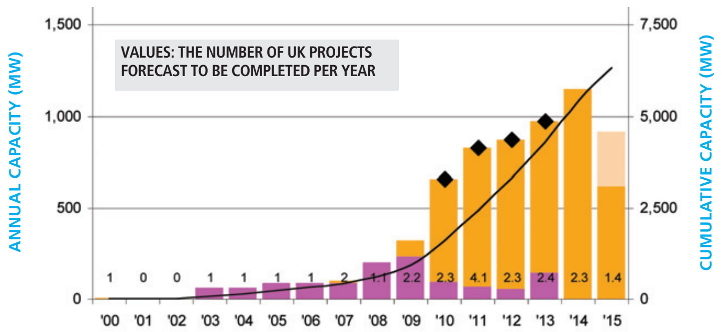
There was a repeated wish for Crown Estate to police the system robustly, for example enforcing the construction timescales in the leases to help avoid companies 'sitting' on good sites.

On associated enabling activities

It is recognised by many that parallel progress needs to be made regarding grid connection points, offshore transmission regulation and in improving consenting arrangements (see Section 3).

Progress with international grid interconnects is also required in order to maximise the benefit of Northern European wind resources in an EU-wide context.

UK Offshore Wind Capacity GRAPH 12
WITH SUPPLY CHAIN LIMITS IMPOSED



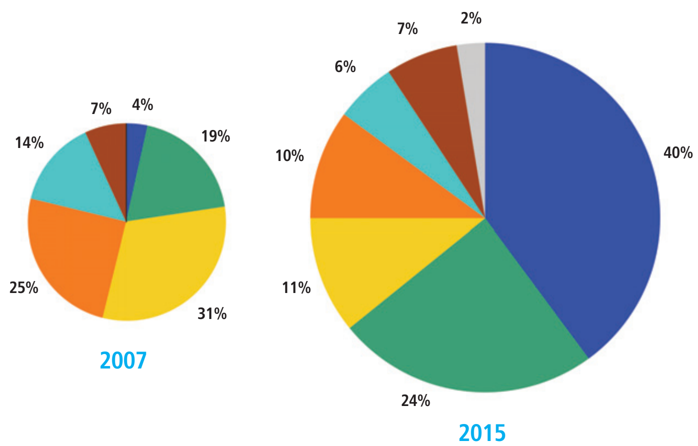
BY END	2000	2005	2010	2015
GW OPERATING IN THE UK	0.0	0.2	1.6	6.3

KEY:
- UK ROUND 1 PROJECTS
- UK OFFSHORE ROUND 2 AND OTHER KNOWN PROJECTS
- UK OFFSHORE FUTURE ROUNDS (INDICATIVE)
- HIGHLIGHT YEARS IN WHICH SUPPLY CHAIN LIMITATIONS ARE FORECAST TO REDUCE INSTALLATION RATES
- CUMULATIVE CAPACITY

NB: IF THE ECONOMICS OF OTHER OFFSHORE WIND MARKETS ARE NOT IMPROVED TO BE IN LINE WITH UK, THEN UK WILL TAKE UP AVAILABLE SUPPLY FIRST AND HENCE WILL NOT SUFFER FROM GLOBAL SUPPLY LIMITATIONS. BASED SOLELY ON UK MARKET REQUIREMENTS, IT IS ANTICIPATED THAT THE SUPPLY CHAIN WILL BE ABLE TO DELIVER FULLY IN ALL ASPECTS UP TO 2015, BUT INVESTMENT TO MEET FUTURE DEMANDS WILL NOT OCCUR.

> *"In the oil & gas sector, independent companies have made major contributions to the delivery of energy. Skills and knowledge in small players have been part of big discoveries. Much of the ability to innovate is located in the small players."*
> DEVELOPER WITH OIL AND GAS BACKGROUND

Make-up of UK Renewables Obligation in 2005 and 2015 GRAPH 13



KEY:
- OFFSHORE WIND
- ONSHORE WIND
- LANDFILL AND SEWERAGE GAS
- CO-FIRING
- HYDRO
- BIOMASS
- OTHER

8 CONCLUSIONS

The overall UK annual installation rate with supply chain limitations imposed, coupled with indication of future round activity is presented in Graph 12.

In recent years, there has been much enabling work by Government, Ofgem, Crown Estate, other stakeholders and the offshore wind sector itself regarding planning, offshore transmission, reform of the RO, development of processes for future site awards and associated environmental and stakeholder assessments. Through installation of roughly one offshore project per year in UK waters, much has been learnt about the technical and logistical challenges of working offshore.

As the Renewables Obligation really starts to impact on the energy mix in the UK, and with negotiation of EU 2020 renewable energy targets expected to be complete in 2008, offshore wind is now well positioned to play a dominant role in using the UK's huge natural wind resource to deliver a significant amount of low-carbon, fuel-free energy.

With the economic environment for offshore wind now sufficient to enable 'good' projects to be developed commercially, there is the opportunity for significant investment at many levels within the offshore wind sector within a long-term policy framework. With encouragement, much of this activity can come from UK businesses, adding significant value to the UK economy.

To 2015, the UK offshore wind market is forecast to be twice the size of any other national offshore wind market. With the experience and expertise already located in the UK, not least from the marine and oil and gas sectors, the UK can secure for itself the status 'leader in offshore wind', with centres of excellence in core skills.

Without this, much of the benefit of the £40bn+ that will be invested in the sector to 2020 will go elsewhere. Indeed, in a competitive environment between European countries needing offshore wind to help deliver 2020 renewable energy targets, the UK may need a fair amount of the value-chain home-based in order to secure delivery. In other words, there is a risk that critical path items will be supplied to continental home markets rather than competing international markets under political and economic pressure from governments attempting to meet stiff EU targets.

Focus needs to be kept on a number of key areas, all of which are required in order for the sector to deliver. These include:

Consenting.

The offshore transmission regime.

Onshore grid connections.

Establishment of other strong offshore wind markets in the EU to enable collective learning, provide increased chance of continuity, and maximise investment and lifetime cost reduction.

In time, the creation of pan-European electricity transmission networks in order to maximise the value of the offshore wind resource.

Development of supply chain, in line with the recommendations provided in Section 5.

Based on the above forecast for 2015, the progress of offshore wind in delivering significant amounts of renewable energy is demonstrated in Graph 13. Historical data is taken from Ofgem (for 2005/6); forecasts for other technologies from Oxera's supporting document to the Energy White Paper, Reform of the Renewables Obligation, May 2007 (Scenario 6) for 2015/6. Note the relative size of the charts reflects the relative total renewable generation in the two years.

"We've passed the point of no return for offshore wind – it will happen on a big scale."

UTILITY DEVELOPER

9 FEEDBACK

Input received and the openness with which it has been given to date has once again been much appreciated. Comments on this report are welcomed, in order to continue to improve the understanding within the offshore wind sector.

Appendix A Notes on Methodology

Background

BWEA held a one day workshop in 2005 to review the current status, successes and failures of the offshore wind sector and gain consensus on the key focus areas to improve rates of installation, which were identified as:

Project economics.
Alternative forms of contracting are needed to spread the risk more equitably. More communication within industry required and earlier involvement desired by the supply chain.

Grid issues (for some projects/areas).
In advance of the 2006 Energy Review, BWEA wanted to present to the Government a unified industry view about what the industry could deliver and what support was needed from the Government in order for offshore wind to provide a significant contribution to the UK's energy mix and economy. With Renewables East, it commissioned the independent report Offshore Wind: At a Crossroads, which provided evidence to support BWEA's claim that the offshore wind industry could indeed deliver significant capacity towards UK 2015 renewable energy targets as long as the economic environment was changed sufficiently for 'good' projects to be developed.

This report

This report provides an update to Offshore Wind: At a Crossroads in line with the purposes and timing discussed in Section 1.

The principal method of collecting the information was by confidential interview with all of the major offshore wind developers, supply chain companies and national wind energy associations. Factual input, company and personal views were received and mirrored back in writing to interviewees for approval under a number of different levels of confidentiality, including:

Input may be published and be attributed / will not be attributed / may be passed to BWEA but will not be published directly / will not be passed on or published.

The following have been interviewed as part of the study:

A2Sea, ABB, Airtricity, Amec, Arreva T&D, Bard, Bladt, Bundesverband WindEnergie, Camcal, CB&I, Danish Wind Industry Association, Darwind, DONG, Draka, Eclipse Energy, EDF Energy, Engineering Business, E.ON UK Renewables, Farm Energy, Gamesa, GE Wind Energy, Global Marine, JDR Cable Systems, KBR, Mammoet Van Oord, MPI, Multibrid, Nexans, Nederlandse Wind Energie Associatie, Nordex, Norsk Hydro, npower renewables, Prysmian, REpower, Scanrope, Scottish Power, Siemens T&D, Siemens Wind Power, SIF, Subocean Group, Svensk Vindkraft, Talisman, Vestas Wind Systems and Warwick Energy.

Informal input from others has also been gratefully received.

UK Projects analysed included all Round 1 and Round 2 projects plus Beatrice activities, Aberdeen Bay and Atlantic Array wind farms. In the EU, around 160 projects were included.

UK Forecasts

Forecasts were generated for the following two cases. The processes involved were kept as similar as possible to those of the previous report in order to facilitate fair comparison.

CASE 1

Based on input from developers only – not supply chain. This has some level of supply chain limitation inherently 'built in', as no developer expects to receive turbines immediately upon order, for example.

and

CASE 2

With input also from supply chain. This introduces additional capacity limitations in some periods, as the forecast demand for wind farm components outweighs the forecast supply capability.

CASE 1
WITHOUT ANY SUPPLY CHAIN LIMITATIONS IMPOSED

A time plan was established for each project. Developers provided a positive 'realistic optimistic' time plan (target plan; 20% chance of meeting) and negative fall-back plan (20% chance of failing to meet, but not including open-ended delays due to economics).

From these data, a mid time plan was derived, assuming a 20% chance of the project being delivered to the positive plan, 20% to the negative plan and 60% half way between these two.

Phased installation was taken into account where applicable. The probabilistic approach gives rise to fractions of projects installed in a given year and results in a 'most likely' scenario.

A probability of completion also was estimated for each project. These were derived as follows:

> **First, each developer was asked to provide these probabilities for each project, as well as a milestone plan for the project and summary of key issues.**
>
> **Second, all the probabilities were moderated based on our view of progress to date, company intent and site viability for each project.**
>
> **Finally, the probabilities were moderated by relative comparison with other projects.**
>
> **Overall, for the projects where developers provided probabilities, the moderation process decreased the installation forecast by 3%.**

CASE 2
WITH SUPPLY CHAIN LIMITATIONS IMPOSED

For Case 2, an annual limit on total capacity (MW) was derived for key elements of the supply chain. An overall global limit for each year was then set, taking into account the element of the supply chain with the lowest forecast available capacity. Annual installation capacity in each country was then modelled by delaying projects if sufficient supply chain capacity was not available, assuming equitable distribution of limited supply across the global market. A 30% mortality rate per year for each MW of installed capacity delayed was then applied, with the resulting carry-over demand added to the subsequent year's demand.

EU and global forecasts

Basic project data for all known offshore projects was collated and distributed to relevant national wind energy associations for review and comment. Feedback was received, and discussion covered not only specific projects but also the political frameworks supporting the development of renewables (and offshore wind in particular). Based on this discussion and expectations of total installed capacity provided by associations, probabilities of completion were applied to all EU projects before aggregation of time plans, using a somewhat simpler method than that described for the above (i.e. no phased build except for very large projects).

Aggregate UK forecasts were generated, then combined with EU and global offshore forecasts in order to form the basis of interviews with the supply chain. This basis was presented to developers for comment before use.

Once input had been received and aggregated, a draft report was issued for peer review and detailed feedback incorporated into this final report.

Appendix B
Impact of Future UK Offshore Wind Site Awards on the Delivery of UK Renewable Energy Targets

This Appendix considers future UK offshore awards, indicative build-out rates and their impact on the delivery of UK renewable energy targets.

Graph B1 considers time taken from date of project award to date of first operation for Round 1 and Round 2 sites based on the data already presented in Section 4. The data for Round 2 projects are offset compared to those for Round 1 projects in order to reflect an approximate three-year difference in award date between Round 1 projects (April 2001) and Round 2 projects (December 2003). As shown, it is anticipated to take 9 to 11 years from award to install 50% of the total anticipated capacity for a given round. The overall success rate for Round 1 installation is calculated to be 80%; for Round 2, 70%. Note that some Round 1 sites were at an advanced stage of development before award, hence some very rapid build-out rates were seen in the first few years of Round 1 activity.

The trends shown above are used to derive a build-out forecast for a typical future round of awards based on good-practice learning but no step-change in process between award and commissioning of a project. There is currently good dialogue underway between stakeholders which is likely to improve these processes, hence reducing timescales and increasing likelihood of successful build of awarded projects. Notwithstanding this, it is anticipated to take nine years from award to install 50% of the total anticipated capacity for that round, with a spread as shown in Graph B2.

Though all projects have specific issues, in simple terms, the programme for a typical large future-round project (optimistic – without delays) is assumed to be as shown in Graph B3. Award is assumed to be at the start of Year 1. With some level of slippage likely at some stage of each project, it can be seen how the above distribution of build-out rates is reasonable.

As an indication, the Graph B4 presents a build-out forecast assuming a 70% success rate for awarded projects, with 5GW awarded each year over the six years 2010 to 2015 (total 30GW). This gives an additional 12GW capacity by 2020 with a further 12GW installed after 2020.

Combining this indication with the supply-chain limited forecast from Section 6 gives a total capacity of 20GW by 2020, as shown below.

Note that there are opportunities to decrease the build-out time and increase the likelihood of projects reaching completion through cooperation between key stakeholders. A one-year reduction in build-out time would provide an additional 3.5GW capacity by 2020. Similarly, a 10% increase in success rate would provide an additional 1.8GW and an extraordinary 12GW award for Dogger Bank in 2013 would give around an extra 5GW by 2020.

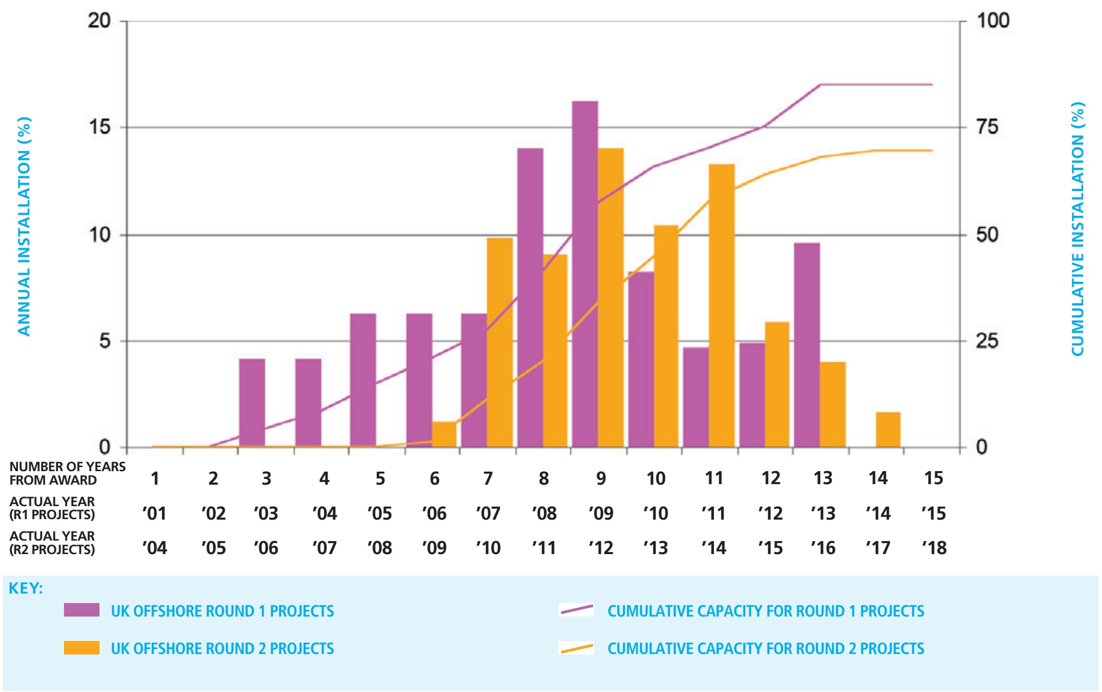
Viewed another way, with a combination of reduced build-out time and a 90% success rate for project completion, the schedule of awards could be reduced to 3GW per year for six years (total 18GW). This has the knock-on benefit of reducing stakeholder workload and 'wasted' development costs on projects that fail.

Note that based on experience onshore, by 2020 plans for upgrading (repowering) offshore wind farms with latest technology is likely to be underway. Implications of such activities are not considered here.

UK Offshore Wind Capacity – Rounds 1 and 2

GRAPH B1

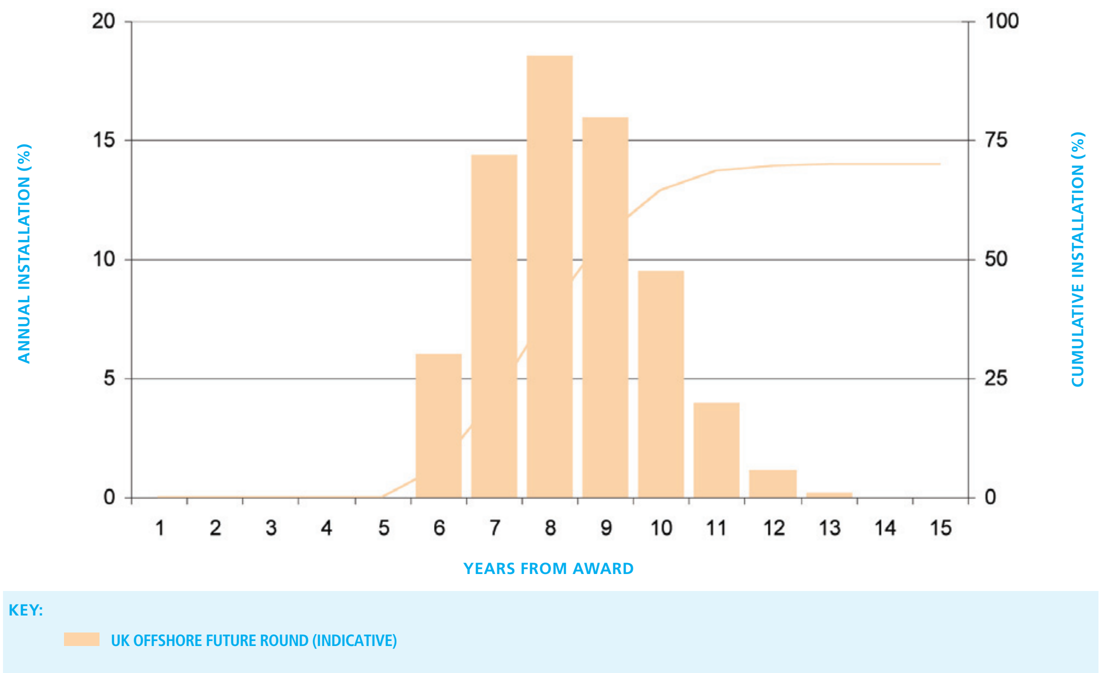
% CAPACITY INSTALLED BY YEARS FROM AWARD



UK Offshore Wind Capacity – Typical Future Round

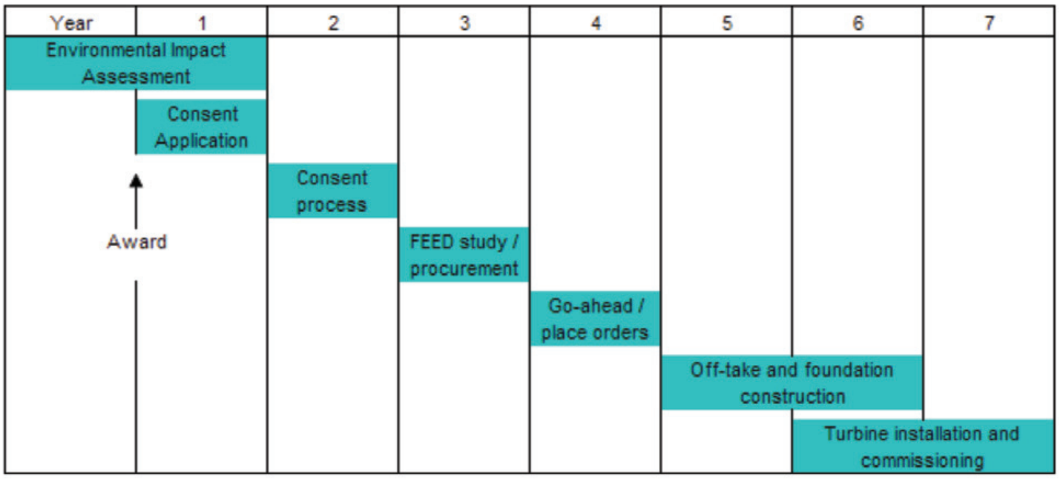
GRAPH B2

% CAPACITY INSTALLED BY YEARS FROM AWARD



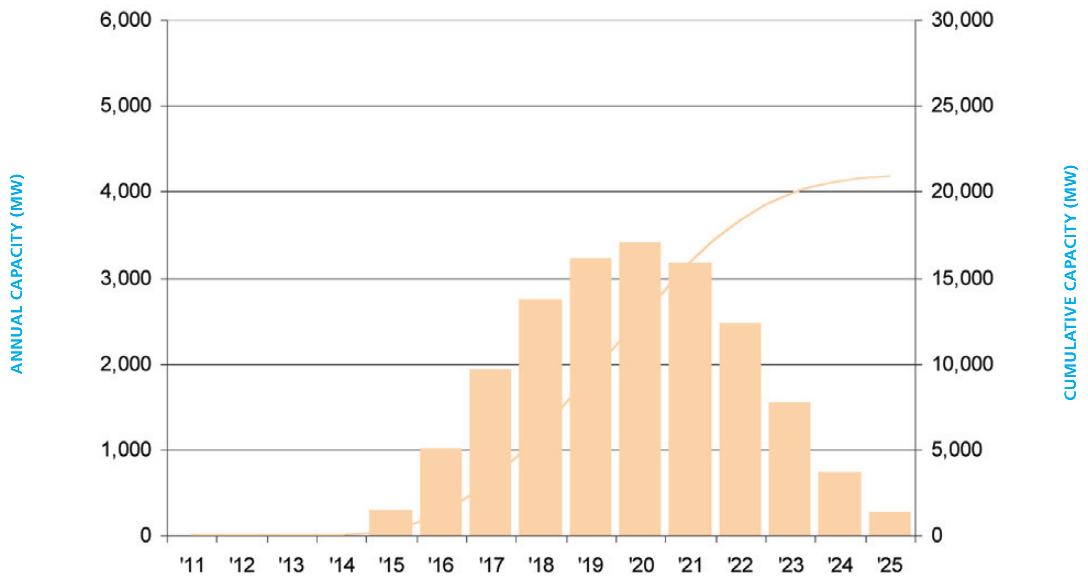
Indicative Programme for a Typical Large UK Offshore Wind Project

GRAPH B3



UK Offshore Wind Capacity – Future Rounds

GRAPH B4



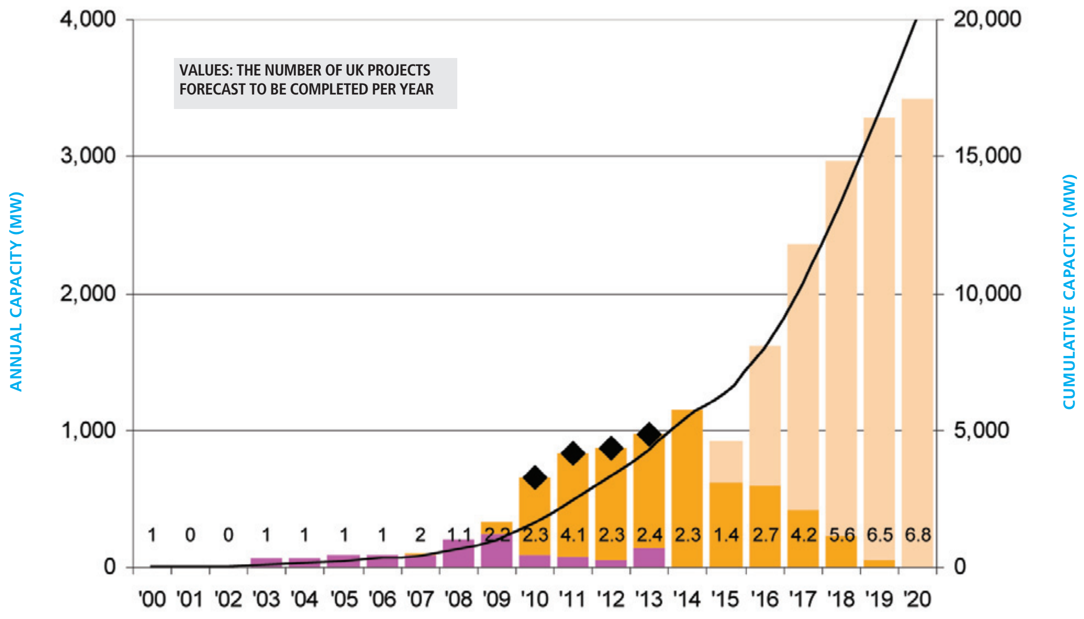
KEY:

UK OFFSHORE FUTURE ROUND (INDICATIVE)

UK Offshore Wind Capacity

WITH SUPPLY CHAIN LIMITATIONS IMPOSED

GRAPH B5



KEY:

- UK OFFSHORE ROUND 1 PROJECTS
- UK OFFSHORE ROUND 2 AND OTHER KNOWN PROJECTS
- UK OFFSHORE FUTURE ROUNDS (INDICATIVE)
- HIGHLIGHT YEARS IN WHICH SUPPLY CHAIN LIMITATIONS ARE FORECAST TO REDUCE INSTALLATION RATES
- CUMULATIVE CAPACITY

Appendix C Selected Project Data

This section provides a summary of selected data for UK and EU offshore wind farms. It is intended to give a snapshot of the expectations of supply needed to service the market and to help focus future investment and technology development activities. All known projects are included, but a probability of completion is applied so that the quantities stated match the UK and EU forecasts presented in the report, without any supply chain limitation imposed.

UK Projects – Turbine Size, Water Depth and Installation Vessels

Graph C1 shows how the use of large turbines is forecast to progress. Up to 2005, all turbines installed offshore in the UK had been 2 or 3MW turbines. Since April 2006, we have seen installation of the first 3.6MW and 5MW turbines, and after 2010 developers expect that such turbines will dominate the market.

A similar pattern exists with water depths. Up to 2005, only projects in average water depth (LAT) of less than 15m had been developed. During the period up to 2010, most foundations will be in 15 to 30m of water, with no other deep water foundations (as required for the Beatrice demonstration wind farm) planned. Beyond 2010, a larger fraction of deep water foundations will be required, but there is no expectation for the use of very deep water (or floating) foundations up to 2015.

These two parameters are the most influential in defining foundation and turbine installation vessel requirements; hence, from the data presented, approximate requirements for foundation vessels can be derived, recognising the general trend that larger turbines will be used in deeper water.

UK Projects – Offshore Substations, Subsea Cables and Cable Installation Equipment

Two potential supply chain bottlenecks are offshore HV substations and subsea cables. Estimates of developer requirements are presented in Graph C2. The first offshore HV substation used on a wind farm in UK waters was at Barrow. As projects move further off the coast and grow in size, the requirement for offshore substations with associated switchgear and transformers will increase rapidly.

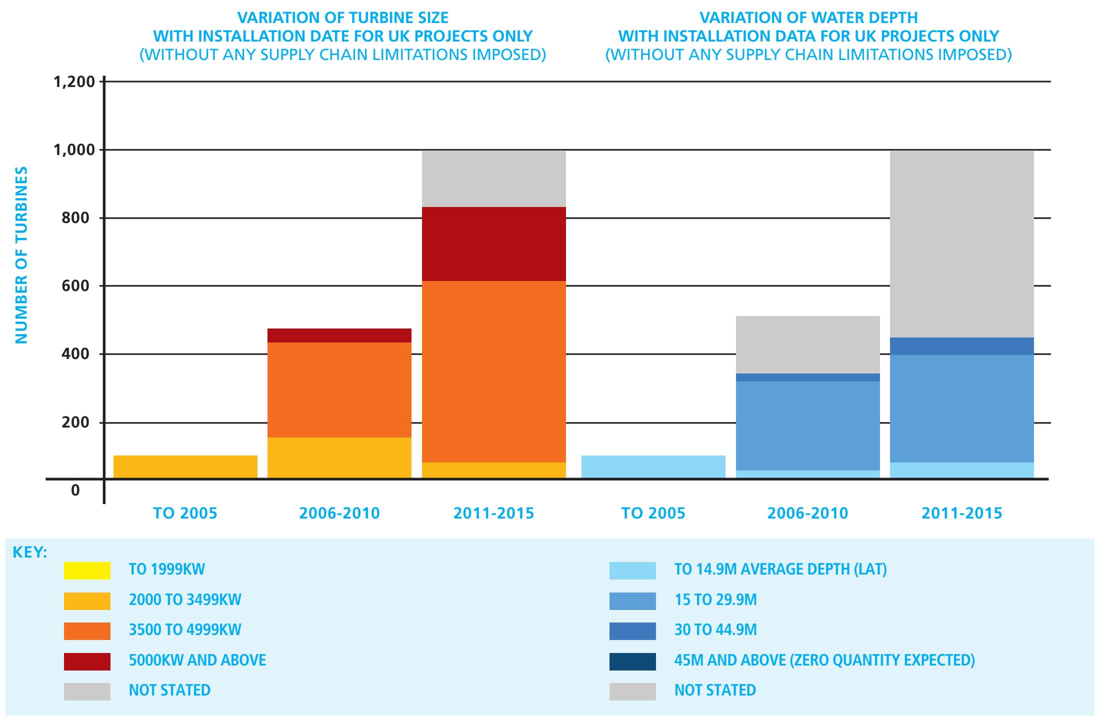
The length of medium voltage (MV) cable required per MW drops as turbine size increases. This is because the number of turbines decreases a little faster than the distance between them increases. The amount of high voltage (HV) cable increases with distance from the shore.

The requirement for cable installation vessels and equipment follows the same pattern as for cables; hence from the data presented, vessel requirements can be established.

All EU Projects (inc. UK) – Turbine Size and Water Depth

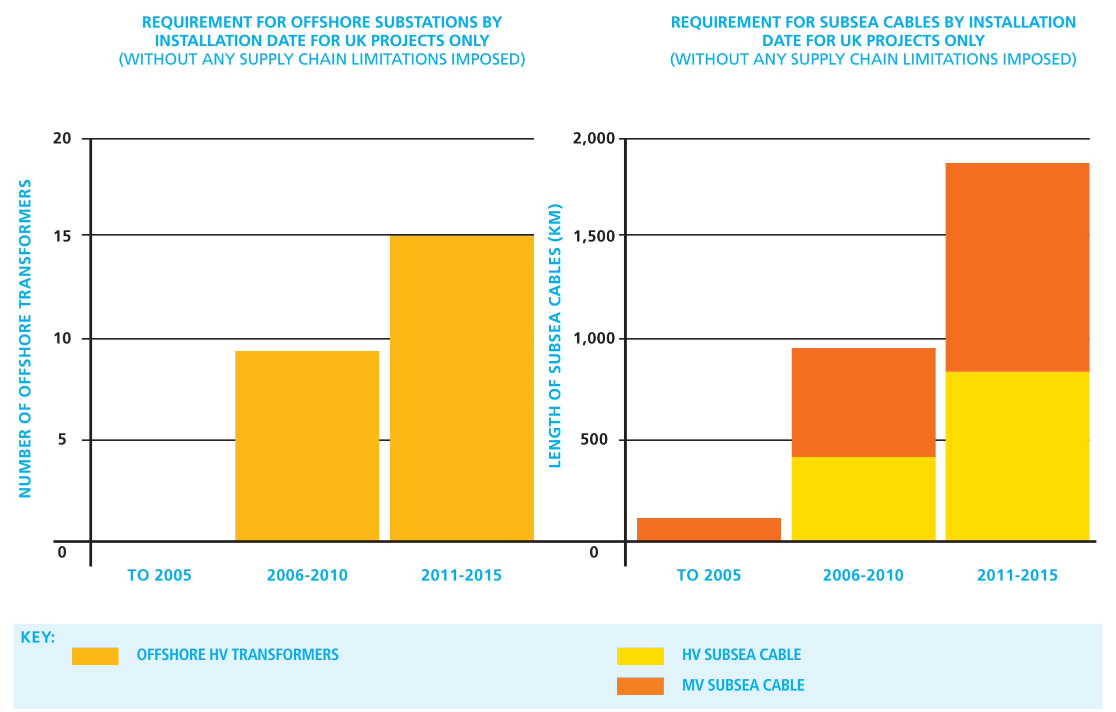
The same progression of turbine size and water depth is presented in Graph C3 for all known EU offshore projects. The figures show that there is an expectation of use of more 5MW+ turbines earlier on the continent than in the UK. This is a reflection on the number of German offshore projects sited fairly far from the coast and in fairly deep water, increasing the relative attractiveness of larger turbines. Only beyond 2016 are projects planned in water depths greater than 45m.

Projected Turbine Size and Water Depth for Future UK Projects GRAPH C1



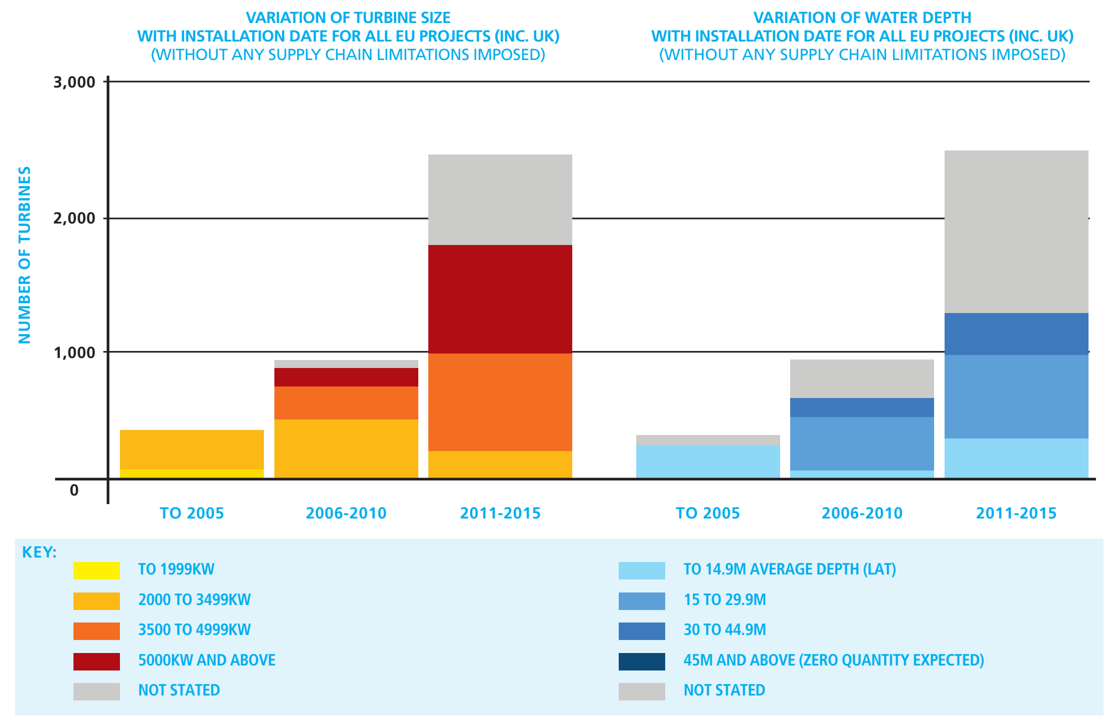
Projected Requirement for Offshore Substations and Subsea Cables for Future UK Projects

GRAPH C2



Projected Turbine Size and Water Depth for Future EU Projects

GRAPH C3



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