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EC HARRIS
BUILT ASSET
CONSULTANCY

Offshore Wind Cost Reduction Pathways

Supply Chain Work Stream

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Executive Summary

Context

This report has been produced as part of the Crown Estate's Offshore Wind Cost Reduction Pathway (OWCRP) study which aims to provide robust evidence of cost reduction opportunities to government, industry and DECC's Cost Reduction Task Force.

Figure 1: Sites and Story definitions

Sites			
Site	Water Depth	Distance from Port	Wind Speed
Site A	25m	40km	9.0m/s
Site B	35m	40km	9.4m/s
Site C	45m	40km	9.7m/s
Site D	35m	125km	10m/s

Stories		
Story 1	Slow Progression	1GW/yr, 31GW in Europe by 2020 out of which 12GW in UK
Story 2	Technology Acceleration	2 GW/yr, 36GW in Europe by 2020 out of which 17GW in UK
Story 3	Supply Chain Efficiency	2GW/yr, 36GW in Europe by 2020 out of which 17GW in UK
Story 4	Rapid Growth	3GW/yr, 42GW in Europe by 2020 out of which 23GW in UK

The OWCRP study covers three work streams: technology (undertaken by BVG Associates), finance (carried out by PricewaterhouseCoopers) and supply chain (led by EC Harris) all focused on ascertaining possible cost reduction opportunities in the industry from now to Financial Investment Decision (FID) 2020 and at two intermediate points FID 2014 and FID 2017.

The results from the work streams are analysed in terms of their impact on the Levelised Cost of Energy (LCOE) over time along a number of cost reduction pathways. The pathways are determined by a combination of site characteristics and stories (see Figure 1).

Aim and Approach

The objective of the supply chain work stream is to ascertain the role of supply chain factors in contributing to cost reduction; and in particular to the achievement of a target cost of £100/MWh by 2020. Engagement with industry has been central to the study via focus interviews and validation workshops carried out with 54 entities across the supply chain. Levers that reflect the role and ability of the supply chain to affect savings, in isolation from technology change and financial issues have been explored with industry. These include: Competition from European players and from Low Cost Jurisdictions, Vertical Collaboration, Asset Growth and Economies of Scale, Horizontal Collaboration, Contract Forms/terms and Uncontrollable Risk (these are defined in detail in the main body of the report).

Key Results

Savings are presented as percentage cost reductions over the OWCRP Study's 2011 baseline's capex and opex (summarised in Table 2). They do not consider fluctuations in currency, changes in commodity prices and ***they are over and above any cost reductions associated with technology innovation and finance issues.***

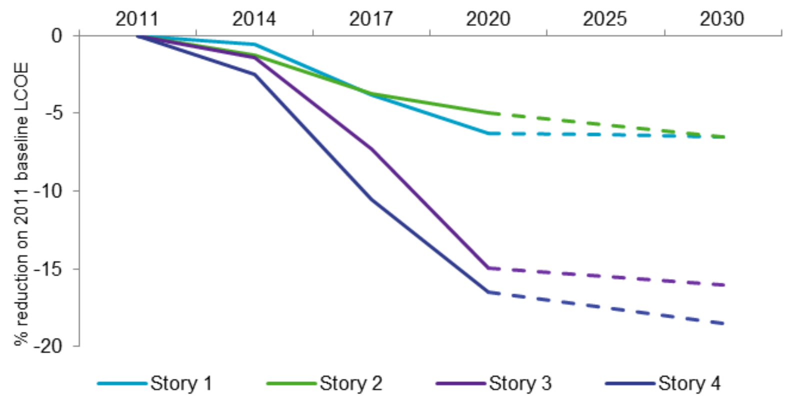
The Supply Chain Efficiency story (Story 3) has been used as the supply chain stream's central case as it provides the most suitable evolution of the current situation for maximising supply chain benefits. Accordingly, industry engagement focused on obtaining detailed data on how under Story 3 the supply chain may impact LCOE and approached the other stories (1,2 and 4) as variants of the central case (Story 3). The principal summary of the stories is given below.

Story 3: Supply Chain Efficiency

Through discussions with industry, it was agreed that by FID 2020, a maximum 15% fall in LCOE over the 2011 cost baseline could be achieved by the supply chain.

This is mainly driven by increased competition (4% fall in LCOE due to more European players and 3% from new entrants from the Far East and low cost jurisdictions), vertical collaboration (4% LCOE reduction) and asset growth and economies of scale (3% fall in 2011 LCOE)

Figure 2: Supply Chain Cost Reduction Pathways



Under this story some of the savings are achieved by locating manufacturing capability in the UK thus increasing the UK content of the offshore wind industry from current levels of 10 to 50%[1]. The less significant levers being; horizontal cooperation with a 2% LCOE reduction impact over 2011, changes in contract forms and uncontrollable risk with 1% LCOE fall each.

In pure capex terms rather than considering LCOE, the wind farm elements with the greatest potential for supply chain capex reductions are installation (30% cost reduction from 2011 baseline by FID 2020), support structures (20% cost reduction from 2011 baseline by FID 2020) and wind turbines (25% reduction from 2011 baseline by FID 2020). Opex reductions of up to 30% over today's levels were put forward for Operation and Maintenance (O&M) but realisable through a longer period (up to 2030).

Story 3 depicts a market of 17GW of operational capacity in UK by 2020 (36GW in Europe, including UK) with deployment rates of 2GW/yr (average). The current uncompetitive segments in the industry become competitive with up to six wind turbine Original Equipment Manufacturers (OEMs) supplying the UK and EU market, at least ten manufacturers of large jackets and enough installers to offer buyer's choice. There is also an increasing presence, albeit still limited, of players coming from the Far East offering lower cost solutions. O&M remains strongly linked to OEMs as the number of operational turbines out of warranty is still low thus limiting the opportunity to develop competition and reduce costs significantly.

In order to deliver the required volume and encouraged by market size, industry deepens vertical collaboration from today's levels. Increased vertical collaboration reduces costs as it limits the amount of reworking necessary; it optimises processes and allows the supply chain to plan more adequately. There is also active management of interfaces both across wind farm elements and within supply chains. This brings significant benefits as it reduces contract contingencies and cost overruns.

There is significant scope for savings relating to asset growth and economies of scale across all elements of the wind farm but particularly in support structures and installation. The proposed cost reductions result mainly from increased productivity coming from greater volumes (sweating production and plant assets thus spreading fixed annual overheads over more utilisation days), standardisation, from spreading investment of long lead items over longer periods and from confidence to build more modern, state of the art equipment which will work more efficiently.

There are significant savings that may be accrued due to cooperation across peers, particularly establishing industry wide standards, training and sharing assets (both equipment and people), but the potential is limited by the industry's insular nature and focus on protecting Intellectual Property (IP).

In terms of cost saving potential across the different sites, the results of the analysis and industry consultation suggest that from a supply chain perspective there is no difference between the sites though there are some technology implications (covered in the technology work stream report prepared by BVG).

[1] 'UK content analysis of Robin Rigg offshore wind farm', BVG Associates, September 2011.

Cost savings will be realised slowly in the first half of the period due to the impact of early collaboration and changes in contractual arrangements with a ramp up from 2016-2017 due to the impact of increased competition.

Story 1: Slow Progression

Story 1 depicts a market with 12 GW of operational capacity in the UK and 31GW in Europe by 2020 (including UK). As a result of industry engagement it was agreed that by FID 2020, the supply chain could affect 6% fall in LCOE over the 2011 baseline. These savings would stem from gaining economies of scale (2%), competitive pressures (3%) and vertical collaboration (2%). Story 1 is unlikely to result in an increase in the UK content of the supply chain as deployment rates are not high enough to incentivise manufacturers to locate to the UK and the UK market becomes marginal within Europe. Under this story, technology does not change radically throughout the period thus allowing some economies of scale and standardisation to take place affording cost savings over today. This is particularly the case in support structures and installation where the largest potential for reducing bespoke solutions and introducing standard solutions lays. In order to achieve the volumes suggested under this story, there is the need to increase vertical collaboration from current levels.

The savings accrued under Story 1 take place gradually from today as a result of learning from Round 1 and Round 2 projects and then rise as a result of capacity growth and competitive pressures towards the later part of the period. Sites have the same cost profile as per Story 3 with the difference that as cost reductions are limited, there may be a preference to develop easier sites with the more difficult ones being at risk of not reaching developers' FID thresholds.

Story 2: Technology Acceleration

Story 2 is characterised by rapid technology change without the accompanying supply chain maturity. Technical innovations across all the elements of the wind farm are introduced. The market develops 17GW of operational capacity by 2020 in the UK and 36GW in Europe (including UK) with an average deployment rate of 2GW/year as per Story 3.

During the focus interviews and workshops, it was agreed that Story 2 is likely to present challenges in terms of its potential to achieve significant cost reductions from a supply chain perspective. For example, the rapid introduction of new technological solutions means that the market, albeit the same size as that developed under Story 3, remains fragmented with only a few players able to supply the different technology segments and the supply chain cannot exploit efficiencies as technology changes rapidly. The market is perceived as more risky due to rapid technology change and investment in asset growth is more guarded as there is a concern that the supply chain will develop stranded assets if they invest in the 'wrong' technology. Cooperation across peers is more challenging than in Story 3 and risk management through contractual change more difficult as packages embody significant level of technology risk (new, less proven solutions).

Accordingly, the maximum fall in LCOE over the 2011 baseline is limited to 5% by FID 2020. The cost savings stem from interfaces being either totally designed-out or made simpler, particularly during installation, by some standardisation mainly in support structures (jackets) where increasing turbines size may be dealt with by changing modular designs rather than designing complete bespoke solutions.

The savings accrued under Story 2 take place gradually from today. Sites have the same cost profile as per Stories 3 and 1 but difficult sites may be easier to develop aided by larger turbines thus requiring fewer trips offshore, innovative support structures, installation methods and O&M practices.

Story 4: Rapid Growth

The Rapid Growth story includes the supply chain developments achieved under Story 3 together with high levels of technology evolution, the introduction of multiple technological solutions and greater levels of investment. In comparison to Story 2, the supply chain is able to gain greater maturity along the different technology segments and technology risk is reduced and better allocated. The depth of financial markets deepens and the market evolves to 23GW of projects operating by 2020 in the UK and 43GW in Europe (including UK). The deployment rate rises to an average of 3GW/year allowing more new entrants.

During discussions with industry, it was decided that only a further 1% fall in LCOE over 2011 baseline under Story 3 may be achieved by FID 2020 bringing the total LCOE reduction to 16%. Savings greater than this were considered to be unrealistic as the volumes predicated under Story 4 already take the risk of overstretching the market. This could lead to a constraint on resources (including human capital) which would in turn put pressure on costs and counteract some of the advantages proposed by this story.

The cost saving profile of Story 4 is likely to be very similar to that in Story 3 but with greater efforts made to increase UK supply chain and size of manufacturing facilities, larger levels of economies scale related savings and closer collaboration.

The savings accrued under Story 4 follow a similar timeline to Story 3 but more accelerated. Sites have the same cost profile as other stories but focus will be on developing all available sites in order to get the volume. As per Story 2, technological change will help in dealing with the more complex sites.

Sensitivities

The effect of commodity and currency price fluctuations on capital and operational costs were used to derive an associated impact on the out turn levelised cost of energy. The results are summarised in the table below:

Table 1: Summary on capital and operational costs impact on out turn levelised cost of energy

Rate/Price	P10 to P90 range	Capital cost range	Operational cost range	LCOE
Pound - Euro	+/- 15%	+/- 7.8%	+/- 7.1%	+/- 7.0%
Copper	+/- 65%	+/- 1.3%	+/- 7.2 %	+/- 3.3%
Steel	+/- 50%	+/- 5.2%	+/- 1.2%	+/- 3.0%
Concrete	+/- 50%	+/- 0.3%	+/- 0.0%	+/- 0.2%

The LCOE is most sensitive to variations in the pound-euro exchange rates. Hence, certainty in costs can be best achieved by insulating capital construction and operational activity from fluctuations in the currency markets. The effects of commodity prices are much lower, although there is a noticeable impact of both copper and steel commodity prices, suggesting efforts to fix these prices will deliver best certainty in the overall outturn costs. As the modelling is based on jacket foundations, concrete is not a significant contributor to the capital costs and is barely utilised during operations. Hence, even a wide fluctuation in its price has no significant impact on outturn costs.

Pre-requisites

Key pre-requisites to achieving the proposed cost savings were identified:

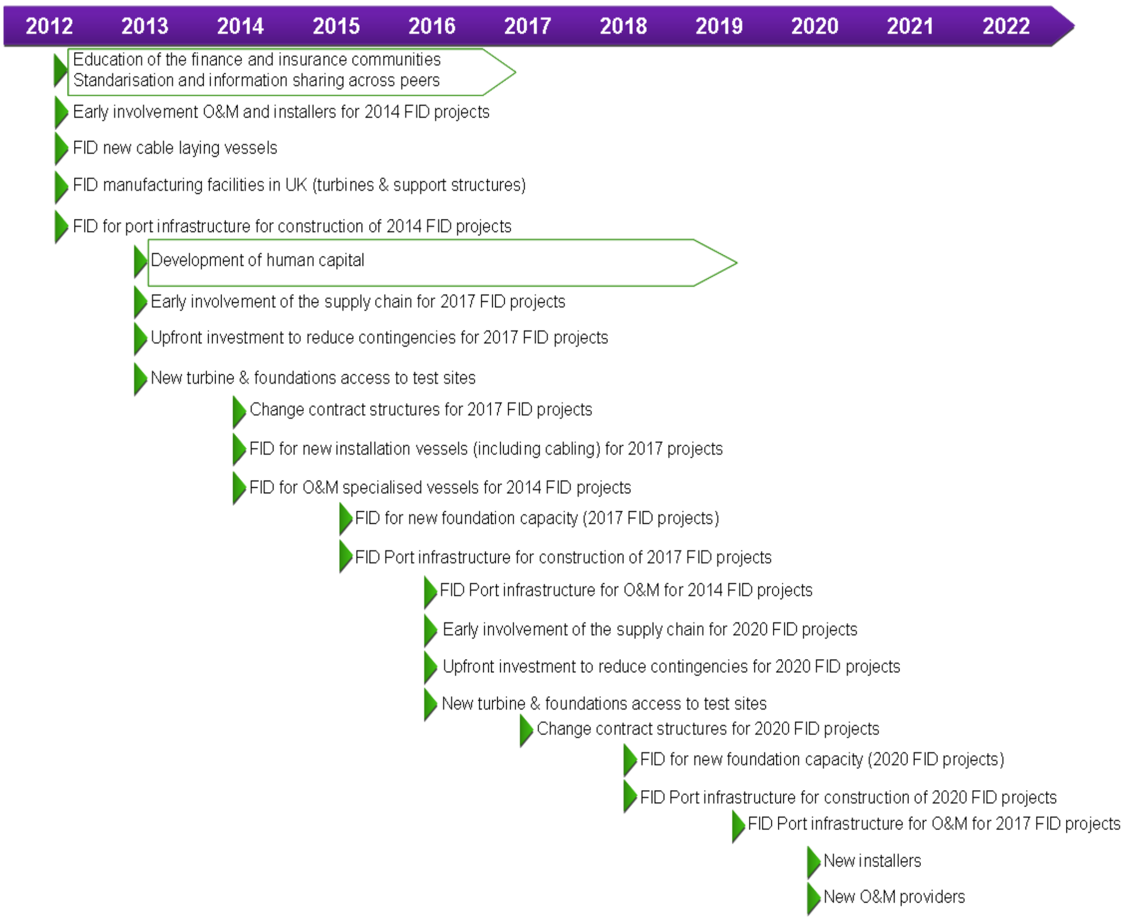
- **Pre-requisite 1: Increase Market Certainty and Volume Visibility**: In order for the offshore wind supply chain to make the necessary investment in new capacity and for new players to enter the market, there is the need for:
  - Certainty over offshore wind financial support (EMR) to 2020 and beyond.
  - A smooth transition from ROCs to CfDs.
  - An examination of the planning process to increase transparency, speed and certainty.
  - Certainty over treatment of offshore transmission assets.
- **Pre-requisite 2: Sufficient Timely Capacity in Prototype Testing Sites:** In order for new entrants to be able to supply the UK offshore wind market, access to prototype sites is required in particular for wind turbines and foundations.
- **Pre-requisite 3: Educate and Engage Finance and Insurance Communities**: The finance and insurance communities need to understand the offshore wind industry more closely in order to facilitate the ability/willingness of to modify current risk allocation practises. The financing community also needs to better understand that funding opportunities in the offshore wind sector extend from Tier 0 (investment in projects) to all tiers in the supply chain.
- **Pre-requisite 4: De-risk Pre-consent Stage**: by for example aiding information sharing across the supply chain in particular relating to sea ground conditions and wind speed will facilitate collaboration.

— **Pre-requisite 5: Common Standards in Place**: Developing technical, operational and contractual standards across the different elements of the supply chain will foster cooperation and reduce bespoke elements. Also, fostering industry wide forums for the discussion of lessons learnt and sharing best practise ensuring that they deliver best value.

— **Pre-requisite 6: Appropriate Levels of Appropriate Human Capital Available**: In order for the industry to develop in a sustainable manner and achieve the proposed cost reductions, it is paramount that the necessary human capital is available in terms of both numbers and skill sets.

For the industry to achieve the cost reductions outlined in this study, decisions need to be made within a certain timeframe.

Figure 3: Story 3 Cost Reduction 2012-2020 Timeline



Overall, pre-requisites 1, 3 and 6, relating to confidence in the market, engagement of the finance community and the availability of adequate human capital, seem the most significant from a supply chain perspective and essential for the achievement of the cost reductions put forward under Story 3.

All pre-requisites apply to the four study stories but their relative importance differs. For example, the requirement for prototype test sites (pre-requisite 2) and the need to educate and engage the finance and insurance communities (pre-requisite 3) is more significant under Story 2 than in Story 3. This is due to the greater introduction of new technology (more testing required and higher technical risk). Pre-requisite 6: Appropriate levels of human capital available, is more important for Story 4 where capacity volumes and deployment rates are higher than in Story 3.

The timing of decisions is also applicable, the key difference being the number of actors that need to make such decisions and whether there is room for slippage in the decision-making process. In Story 1, the fact that volumes are lower implies that fewer supply chain actors need to undertake the activities put forward in the report and thus some of the timings suggested for Story 3 may be delayed. In contrast, Story 4 requires much higher levels of activity, greater number of players being involved, higher levels of investment and a more accelerated timescale in comparison to Story 3 in order to achieve the volumes and associated cost savings.

1 Introduction

1.1 Background

This report has been produced as part of the Crown Estate's Offshore Wind Cost Reduction Pathway (OWCRP) study which aims to provide robust evidence of cost reduction opportunities to government, industry and DECC's Cost Reduction Task Force. Previous studies have examined drivers, explored past trends and analysed potential cost reductions. This project seeks to further existing analysis by:

— Demonstrating high levels of engagement from industry.

— Providing transparency of assumptions and dependencies.

— Adopting a multiple 'pathways' approach.

— Integrating the perspectives of technology, supply market and finance.

Key rationale for this study includes:

— DECC envisages offshore wind to provide the largest portion of renewable energy needed to meet the UK's 2020 EU targets (11-18 GW by 2020) , with potential for more than 40 GW deployed to contribute to the UK's 2027 carbon budgets and beyond.[2]

— Offshore wind costs have risen in recent years and there is uncertainty over the cost of energy going forward particularly from the more challenging Round 3 sites.[3] In order for offshore wind to play a significant role in the UK's renewable energy mix and to be seen as an attractive investment, energy costs need to fall to around £100/MWh.

— The current reforms to the UK's electricity market will define the size of the opportunity for offshore wind to 2020 and beyond. The level of support provided will be influenced by assumptions made about the costs of generation.

— The offshore wind industry needs to make investment decisions in order to deliver offshore wind capacity. Paramount to making such investments is confidence on the size of the opportunity, which in turn is influenced by the industry's ability to reduce costs.

1.2 Aim

The OWCRP study covers three work streams: technology (undertaken by BVG Associates), finance (carried out by PricewaterhouseCoopers) and supply chain (led by EC Harris).

All work streams focus on ascertaining possible cost reduction opportunities in the industry from now to Financial Investment Decision (FID) 2020 and at two intermediate points FID 2014 and FID 2017.

The objective of the supply chain work stream is to ascertain the role of supply chain factors in contributing to cost reduction and the achievement of a target cost of £100/MWh by 2020.

1.3 Approach

The supply chain study focuses on Tiers 0, 1, and 2 of the supply chain, meaning owner/developers (Tier 0), suppliers/manufacturers of key equipment such as whole wind turbines or providers of key activities, such as installation (Tier 1) and suppliers/manufacturers of key major sub-components (vessels, subsea cables) (Tier 2).

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[2] The Offshore Valuation Study, PIRC 2010.

[3] Great Expectations, UKERC October 2010.

In order to explore their potential cost reduction contributions, levers that reflect the role and ability of the supply chain to affect savings, in isolation from technology change and financial issues have been identified. These are defined in detail in Section 3 of this report but are summarised below:

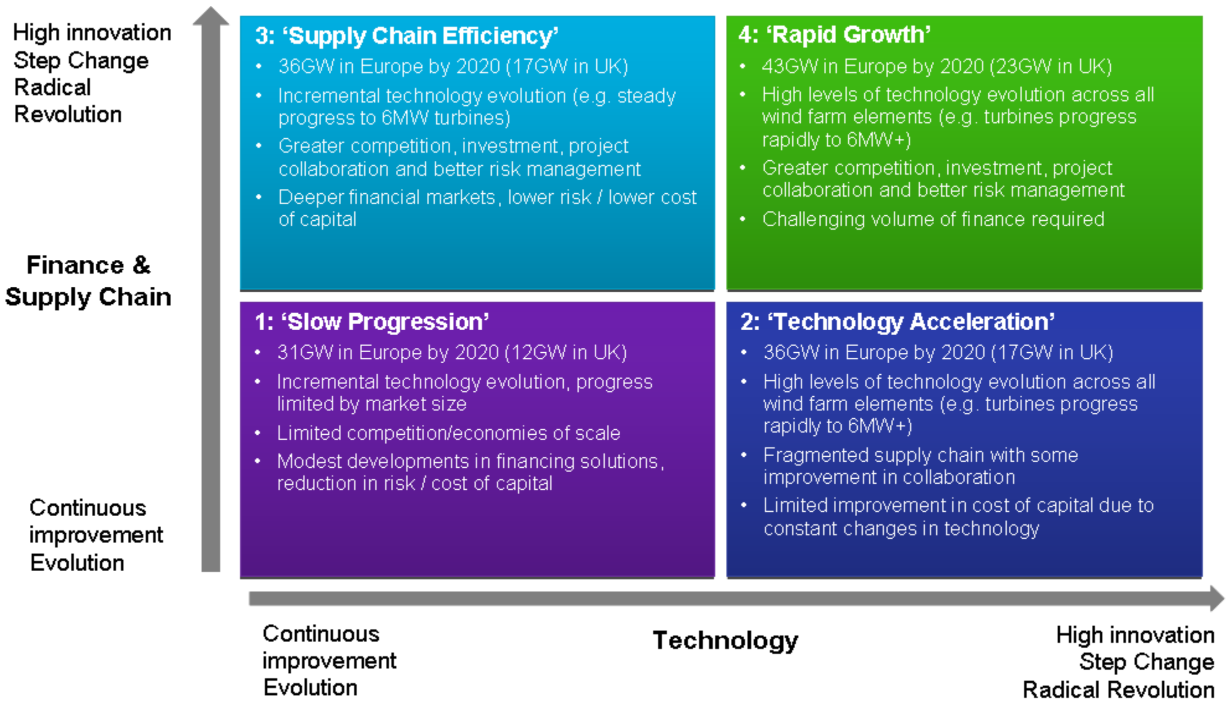
- Increasing the number of European and Low Cost players in the different market segments.
- Improved vertical collaboration, including interface management, down the supply chain tiers.
- Asset growth and economies of scale (AG,ES).
- Increased collaboration amongst peers.
- Changes in contract forms/terms.
- Different means of managing and pricing uncontrollable risk.

This study explores how the above mentioned levers may allow the supply chain to reduce costs. Accordingly, the savings put forward in this report do not include the impact of introducing technology innovations (including changes in manufacturing processes) and of financial issues. ***Supply chain savings are over and above any cost reductions associated with the technology and finance streams.*** In order to isolate supply chain impacts from the other study streams, in particular technology, and avoid duplication of proposed cost savings, a process of moderation was undertaken (which was then validated with industry) which identified instances of overlap and allocated the associated savings to the most appropriate work stream.

Industry also offered some cost saving opportunities that would apply across several supply chain levers. Such instances have been recorded in the text and the level of proposed cost saving adjusted accordingly in order to avoid double counting. This has been necessary in order to isolate the impact of each of the supply chain levers and has resulted in some levers, in particular Contract Forms and Uncontrollable Risk, generally showing lower cost reduction potential than others. Although small, these cost reductions are valid and represent the ‘stripping off’ of other impacts reflected under other levers such as Vertical Collaboration and Asset Growth and Economies of Scale.

The results from the work streams are analysed in terms of their impact on the Levelised Cost of Energy (LCOE) over time along a number of cost reduction pathways. The pathways are determined by a combination of site characteristics and stories. The OWCRP study’s stories attempt to describe the different directions the offshore wind industry may go through to 2020 and beyond as summarised below.

Figure 4: OWCRP Study Stories



Note: All GW figures in Figure 4 refer to installed capacity by 2020.

— Site A: Average water depth 25m, distance from port 40km, average wind speed 9 m/s.

— Site B: Average water depth 35m, distance from port 40km, average wind speed 9.4 m/s.

— Site C: Average water depth 45m, distance from port 40km, average wind speed 9.7 m/s.

— Site D: Average water depth 35m, distance from port 125km, average wind speed 10 m/s.

The Supply Chain Efficiency story (Story 3) has been used as the supply chain stream's central case as it provides the most suitable evolution of the current situation for maximising supply chain benefits. Accordingly, industry engagement focused on obtaining detailed data on how under Story 3 the supply chain may impact LCOE and approached the other stories (1, 2 and 4) as variants of the central case (Story 3).

Engagement with industry has been central to this study. In driving towards an understanding of the potential for supply chain efficiencies to contribute to a reduction in the cost of offshore wind energy, we captured and challenged industry's views and supporting evidence. The cost reduction pathways put forward in this report represent the amalgamated view of industry gathered from a number of focus interviews and validation workshops where we engaged with 54 different entities:

— Thirteen Owner/Developers.

— Nine turbine manufacturers and key component suppliers.

— Three O&M providers.

— Seven support structures providers.

— Eleven installation experts (including vessel providers).

— Four port representatives.

— Two cable suppliers.

— Five service companies.

We have supplemented industry's information with research to identify relevant examples from other related sectors. Instances where the industry's views and data have been supported by EC Harris' independent research are made clear in the text. Having captured industry's data, we critically reviewed it and then validated our understanding with industry experts, in order to ensure accurate and reasonable interpretation of the information received.

Through modelling, EC Harris has been able to understand, across a matrix of wind-farm elements and cost reduction levers, where industry expects supply chain cost savings to be made, how those savings vary for each story and site and the time dependency of when savings will be realised.

The results of this study have been incorporated into a model used to assess changes in LCOE over time using different turbines in changing site types and 'stories' to produce 'pathway' forecasts.

Our methodology followed a structured approach consisting of eight steps:

1. Project plan and development of pathways: During this phase of working together with the other consultants and the Crown Estate team, we planned how to engage with industry, we clarified the wind farm elements to explore, finalised the 2011 baseline and agreed the relevant supply chain cost reduction levers.

2. Test pathways and validate: We worked with the finance and technology work streams to ensure consistency and we validated the cost reduction levers as relevant with The Crown Estate.

3. Industry engagement (Focus Interviews): We engaged with key leaders across the offshore wind energy supply chain through 18 structured focus interviews where we captured their knowledge in a coherent fashion.

4. Supply chain cost reduction pathways model and matrix development: We developed the supply chain cost reduction model and matrix which assimilated the industry knowledge. In order to carry this out, we developed a logical, numerically driven approach to test that knowledge for robustness and criticality (see Appendix A).

5. Research: Where critical gaps were identified in the supply chain matrix, we applied 'point' desk research to fill gaps. The research was conducted to provide examples and insight to support the information captured from the industry.

6. Industry validation (Workshops): We held eight workshops with a large cross-section of representatives from the offshore wind supply chain where we presented the knowledge captured through the focus interviews and the associated supply chain matrix for challenge, comment and validation.

7. Reporting: The captured knowledge and understanding has been assimilated into a report delivering insight on the future supply chain developments for the offshore wind energy sector.

8. Incorporation of supply chain results into the LCOE model. The tools developed for supply chain and technology modelling have been designed together, with identical definitions of wind farm elements and results based on the same assumptions.

A more detailed methodology statement is included in Appendix A.

Terminology and 2011 Cost Baseline

For the purpose of clarity, when referring to the impact of supply chain levers on LCOE in the text of the report, terms such as 'reduction' or 'saving' are used and these are described as quantitative figures. For example, increased competition facilitates an 'X' per cent reduction in LCOE. When these reductions are represented in graphs, they are expressed as negative numbers, i.e. cost reductions.

The 2011 cost baseline against which cost reductions are measured is given in

Table 2. The baseline costs are nominal contract values, rather than outturn costs. Future costs follow the same pattern, incorporating supply chain effects typical of late 2011. This report discusses the impact of changes within the supply chain on these costs, the technology work stream report discusses technical change and the finance work stream report discusses contingency and the impact of risk on lifetime cost.

Table 2: 2011 Study Cost Baseline

	Element [1]	Units	Based on Contract Value
Capex	Project up to FID	£k/MW	150
	Project from FID to WCD[4]		37
	Construction phase insurance		40
	Turbine		**1,024**
	Support structure (inc. tower)		**551**
	Array electrical		**80**
	Installation		**473**
	Contingency		221
	Total		2,355
Opex (Outside warranty)	**Operation and planned maintenance**	£k/MW/yr	**26**
	Unplanned service		**53**
	Other		2
	Operating phase insurance		14
	Transmission charges		69
	Total		164
Annual Energy Production (AEP)	Gross energy production	MWh/yr/MW	4,228
	Wind farm availability	%	95
	Aerodynamic array losses		9.5
	Electrical array losses		1.0
	Other losses		4.6
	Net energy production	MWh/yr/MW	3,482
Decommissioning	Total	£k/MW	307

Source: The Crown Estate and Consulting Team

Note 1: The 2011 baseline is based on 4MW turbines located in Site A and it does not include overall project contingencies.

The supply chain cost reduction pathways focus on the capex and opex elements of LCOE with the greatest scope for the supply chain to influence (highlighted in blue in

Table 2):

— Turbines (excluding tower).

— Array cables (excluding export cable and related infrastructure).

— Support structures (including tower).

— Installation of turbines, support structures and array cables.

— Planned and unplanned Operation and Maintenance (O&M).

[4] WCD = Works Completion Date. The date at which 100% of the capacity becomes operational. (Note that this may be before formal project handover)

The OWCRP does not include an assessment of potential cost reductions relating to transmission assets. These are explored by a separate study.[5]

Treatment of Health and Safety

Maintaining and improving the Health and Safety of offshore wind operations are of supreme importance to the industry's stakeholders, including the Crown Estate. Having talked to industry, the cost savings opportunities put forward in this report are not believed to compromise current levels of health and safety requirements.

Health and Safety was discussed at all interviews and workshops and important issues recorded and combined with evidence from the other work streams. This was then provided to PMSS who analysed the information in depth in a separate report in order to draw overall conclusions.

Treatment of risk

Risk is a common theme across the work streams. The finance stream focuses on developers' risk (installation and operational risk) and it explores how developers account for risk in terms of overall project contingencies and estimation of outturn costs, expressed as a P90 ratio (which represents an estimate of the worst case scenario). The technology stream explores how in the short-term, the introduction of new technology may add uncertainty. The relevant information regarding risk is passed to the finance work stream. The supply chain study focuses on how the supply chain (from Tier 1 down) prices risk and how changes in supply chain behaviour may lead to lower contract prices through pricing risk differently. The impact of supply chain changes on developers' risk has been transmitted to PWC through discussions and through a joined risk workshop and is mentioned where appropriate in the text of this report.

1.4 Structure of the report

This report is structured as follows:

— Section 2 provides an overview of the current status of the UK offshore wind industry setting the scene for potential changes during the period to 2020. This includes commentary on market conditions and expected market trends, key players and presents a market capacity and supply/demand balance.

— Section 3 provides a definition of the study's cost reduction levers and it establishes the current situation for each lever against which the impact of change have been assessed.

— Section 4 presents the results of critical industry engagement and EC Harris' research with an in depth analysis of Story 3: Supply Chain Efficiency by focusing on cost savings across wind farm elements.

— Section 5: presents the supply chain cost reduction pathways across all the different stories drawing on themes from various elements presented in section 4.

— Section 6: presents sensitivities for currency and commodity price fluctuations.

— Section 7 summarises all the pre-requisites that are necessary for the cost savings to be obtained and frames then within the required timeline.

[5] Potential for offshore transmission cost reductions: A report to The Crown Estate, February 2012, RUK.

2 Current Situation

2.1 Introduction

The aim of section 2 is to give an overview of the current status and capacity of the offshore wind industry, setting a baseline from which changes in the period to FID2020 will occur. It includes details of the following:

- The size of the global wind energy market. We look at how the overall wind market is growing, and the increasing potential for Far East-based supply chains to service European markets.
- The size of the offshore market in Europe, and in the UK. The UK has been the largest offshore-wind market in Europe. It also has the largest potential project pipeline. As a result, the UK market is likely to remain attractive, even as other competing Northern European markets expand.
- Logistics and programme constraints – we include an analysis of project timelines based on project-sourced data.
- Key players and potential new entrants. This section describes the number and characteristics of key players in the supply chain. The review includes an assessment of changing supply and demand dynamics over the study period to 2020.
- An assessment of the projected balance of supply and demand. Based on the capacity of current participants, we review available capacity to meet current and forecast demand across Europe. As demand increases in line with forecasts based on the four study stories, there will be the need to unlock new supply by expanding existing facilities and/or investing in new capability.

2.2 The Global Wind Energy Market

The objective of this section is to place the size of the UK and European Offshore Wind markets in the context of the global market for both onshore and offshore wind energy. Data in this section has been sourced from Global Wind Energy Council yearbooks[6], and details the overall wind energy market. This perspective is useful because the offshore wind market is currently a relatively small niche with significant growth potential. This overview puts the discussion on cost levers in section 3 into a global context.

Overall market size

In 2010 the total global wind energy market had available capacity of 197GW, growing by 24% (38GW) in 2010 alone. Growth mainly occurred in Asia (21 GW), with China accounting for 18GW. According to GWEC[7] Offshore wind capacity grew by over 50%, adding 883MW in 2010 – 2.3% of additional global capacity.

The global wind market is very dynamic. The rapid acceleration of wind energy investment in the Far East is illustrated in Figure 5, which plots annual additional and total wind turbine capacity. As Europe's share of new capacity fell to below 50% in 2008, the Far East market boomed. Far East markets accounted for nearly 50% of new capacity in 2010. China's annual rate of installation grew from 6.3GW in 2008 to 18.9GW in 2010 – more than the total installed capacity of Spain, France and the UK combined. The market in India by contrast has remained steady at around 1.8 to 2.4GW per annum. Rapid growth in the Far East has implications for cost reduction levers driven by low-cost competition, as rapid growth in these markets could encourage new entrants and could also increase economies of scale.

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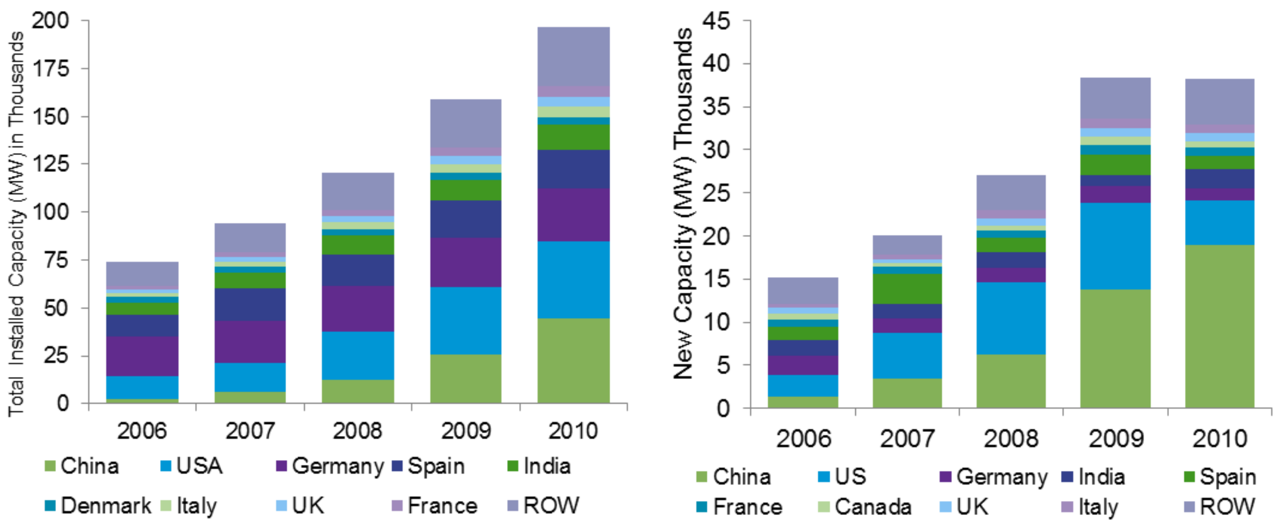
[6] GWEC, Global Wind Report: Annual market update 2010

[7] GWEC, Global Wind Report, 2010, ibid

Figure 5: Story 1: World Wind Markets - Additional and total wind capacity 2006 to 2010



Source: GWEC Global Wind Reports, 2006 to 2010

Key points from the analysis presented in Figure 5 are as follows:

- The Chinese wind market doubled in size year on year from 2006 to 2009 and grew by nearly 50% in 2010.
- Rates of growth in India accelerated in 2010 after a 30% fall in 2009.
- The United States market contracted rapidly in 2010, with the rate of new installed capacity, falling from 10GW recorded in 2009 to 5.1GW. The North American market has gone from being the leading market in 2008, to third place by 2010.
- Rates of growth in new capacity also fell in other major markets including Spain and Germany.

The effects of the contraction in new capacity can be seen in Figure 6 and the analysis of wind turbine manufacturer margins in section 2.5, which looks at turbine manufacturer margins over the period 2008 to 2011. This analysis illustrates the important role of the cost reduction lever, certainty in asset growth, in underpinning investment decisions.

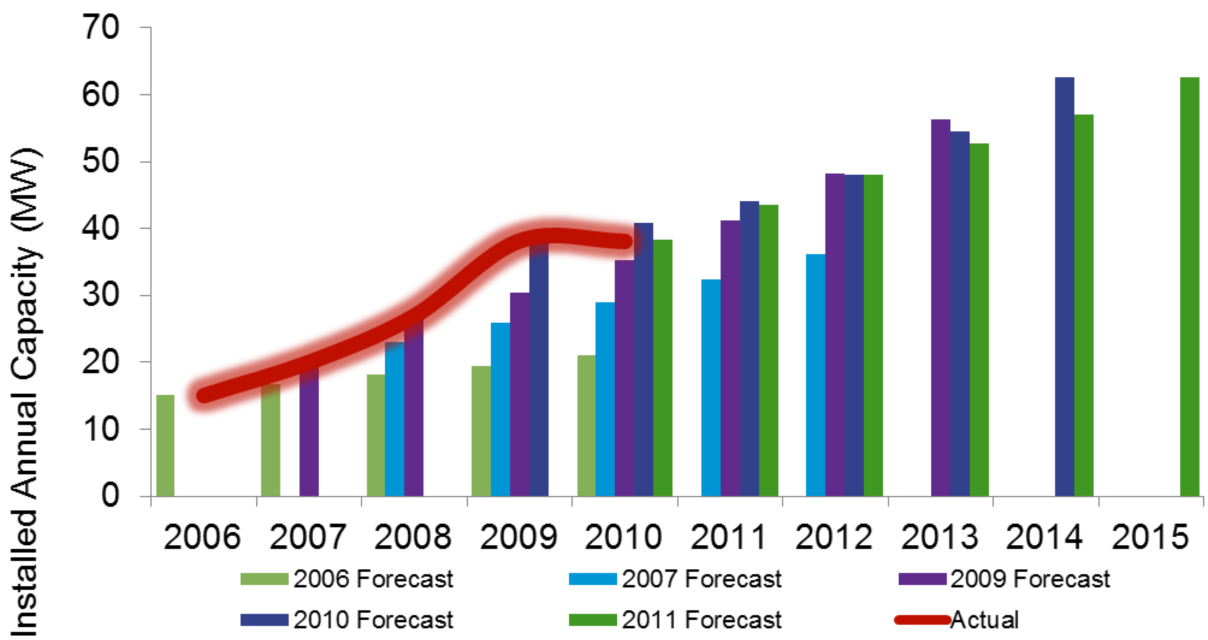
The global wind energy market remains consolidated with 75% of installed capacity located in the top five markets (US, China, Germany, Spain, India). With the possible exception of Spain, which is currently facing challenges around subsidy levels and high installed capacity[8], this pattern is unlikely to change. Based on 2010 data also shown in Figure 5, 75% of new capacity is also being installed in these same markets, with France and the UK being ranked 6th and 7th respectively.

Forecasts for growth between 2006 - 2015 issued by GWEC[9] and detailed in Table 6 indicate that the rapid rate of growth seen in 2010 is expected to continue, increasing from 43GW per annum (2011) to 62GW per annum (2015). This represents a significant acceleration, from the baseline of 38GW installed capacity seen in 2010.

[8] Spanish wind farms produced 60% of all electricity needs during a two-hour period on November 6th, 2001. Source: Green Guide Spain

[9] GWEC, Global wind reports, Annual Updates 2006 to 2010

Figure 6: Comparisons of Forecast Wind Growth Rates 2006 to 2011



Source: GWEC Global Wind Reports 2006 to 2010

Figure 6 sets out a comparison of forecasts from 2006 to 2011 together with data on actual installed capacity – plotted as a line. The histogram plots the available forecasts for each year side by side - showing that long term forecasts to 2015 have been subject to very little revision so far, in response to more challenging market conditions from 2010 onwards, Figure 6 shows that demand outstripped forecast growth from 2007 to 2009 and then slowed very rapidly. Output in 2010 was however still above levels forecast in 2009.

Current forecasts[10] can be summarised as follows:

— Europe is forecast to continue to expand capacity steadily with a rise of 60GW anticipated (up from 86GW in 2011) to 146GW by 2015. The extended economic downturn in Europe could of course have a negative effect on demand for energy and investment, although recent energy policy changes in Germany, Italy and others following the Fukoshima disaster could lead to further opportunities for renewables.

— The North American market is forecast to remain a principal global market, more than doubling capacity from 44GW to 94GW by 2015. This forecast is dependent on a rapid recovery to 2009 volumes by 2013, and in turn is dependent on a number of factors including energy prices and the maintenance of the wind production tax credit beyond 2012.

— Other regions of Latin America, Pacific, Middle East and Africa are anticipated to expand at modest levels.

Forecasts for year 2012 onwards published in 2010 and 2011 do not appear to have been downgraded in response to reduced demand. Our interpretation is that the 2011 forecasts in particular are optimistic, and do not fully account for the steep fall in activity seen in major markets in 2010 – summarised in Figure 5. With changes to subsidy structures taking place in Spain and China and the potential withdrawn of Tax Credits in the US in 2012, these growth rates may prove difficult to sustain.

In conclusion, the global wind energy sector is expected to see very substantial growth over the next five years. However, current growth projections could be subject to revision in view of the current challenging market place. Increased scale will result in greater diversification and should help to attract more market entrants. However, current uncertainty in the market could also affect short term decision making.

[10] GWEC, Global Wind Report, 2010, ibid

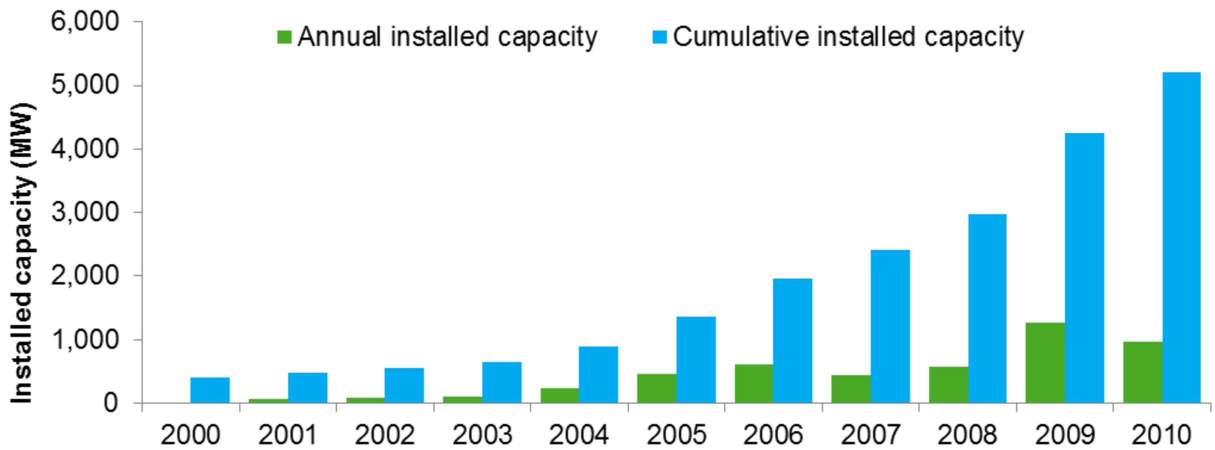
Both factors, scale and short term uncertainty are relevant to a number of cost reduction pathways discussed in section 3, including increased competition and asset growth/economies of scale.

2.3 European Offshore Wind Energy Market

Current Installed Capacity in Europe

The total offshore capacity installed in the European wind market by the end of 2011 is 3.8GW, equivalent to approximately 1.5% of global installed capacity and 4.5% of installed capacity in Europe[11]. Figure 7 illustrates the rapid growth in the offshore sector from a low base since 2006. 866 MW of new capacity was connected in 2011[12], with over half coming from UK sites.

Figure 7: European offshore wind capacity – 2001 to 2011



Source: GWEC Global Wind Report 2010, EWEA, European offshore wind industry key trends and statistics 2011

Table 3 sourced from EWEA summarises total installed wind capacity as of 2011. The UK is currently the market leader, with 55% of installed capacity. The UK and Denmark together account for 77% of installed capacity. A number of countries such as Germany, Netherlands and France are at an early stage of development, but have ambitious expansion plans. 10 projects are currently under construction in European Waters and preparatory work is commencing on 9 projects, which will add 2.4GW and 2.9GW capacity respectively. More detailed analysis of the UK market is provided below:

Table 3: Total Installed Offshore Wind Capacities – Europe 2011

	UK	DK	NL	DE	BE	SE	FI	IE	NO	PT	Total
No of Wind Farms	18	13	4	6	2	5	2	1	1	1	**53**
No of Turbines	636	401	128	52	61	75	9	7	1	1	**1371**
Capacity Installed (MW)	2093	857	247	200	195	164	26	25	2	2	**3811**

Source: EWEA the European offshore wind industry key trends and statistics 2011

The European offshore wind market is at an early stage of development, but has grown rapidly in the past five years. Table 4 compares installation rates for offshore wind and the major European markets – showing that Offshore Wind grew to a European market share of 11.4% by 2010.

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[11] Offshore capacity to end 2011 sourced from EWEA, overall capacity derived from GWEC, Global Wind Report, 2011, ibid

[12] EWEA, "European Offshore Wind Industry, key trends and statistics, 2011", January 2012

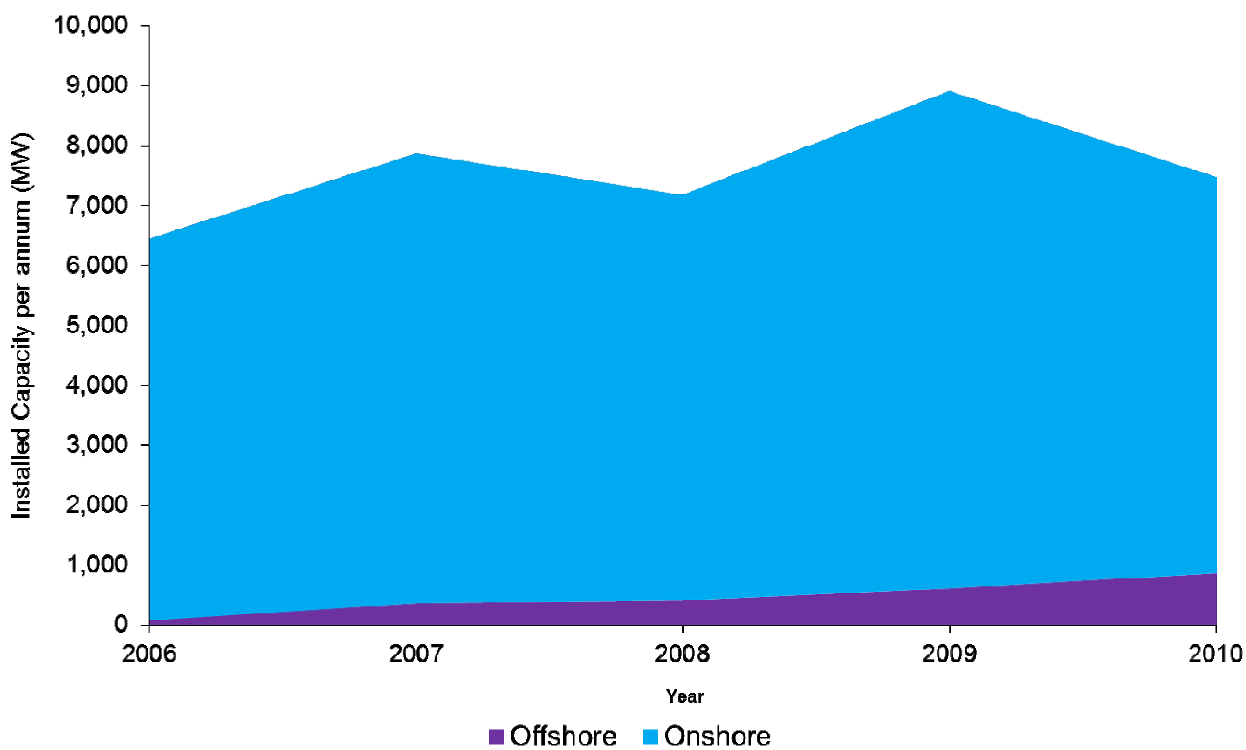
Table 4: Rates of capacity growth in major European Markets, 2006 to 2010

	2006 (MW)	2007 (MW)	2008 (MW)	2009 (MW)	2010 (MW)
Onshore Wind (MW)	6,361	7,520	6,772	8,304	6,612
Onshore Wind (year on year %)		18	(10)	22	(20.5)
Offshore Wind (MW)	77	343	400	600	854
Offshore Wind (year on year %)		345	16	50	42
Offshore market share (%)	1.2	4.4	5.6	6.7	11.4

Source: EC Harris and GWEC

This data is plotted in Figure 8 illustrating the relative small scale of the European offshore market, and the rapid but steady rate of growth recorded in the segment since 2006. By contrast the more mature onshore market has seen volumes fluctuate by 10 to 20% on a year to year basis. To place the demand stories into the context of current levels of activity, the peak additional annual capacity to be added to UK offshore wind is projected to range from 3.2 to 3.6GW per annum. This equates to a 7 times increase on the current rate of installation in UK waters.

Figure 8: Growth in European Installed Onshore and Offshore Wind Turbine Capacity – 2006 to 2010



Source: GWEC 2006 to 2011

The implications of this assessment is that onshore wind is expected to remain the dominant segment, competing with the offshore market and other industries for resources and investment as demand for renewable energy ramps up.

The UK Offshore Wind Segment

The UK has built a leading position in the European offshore market with 2.1GW in operation, comprising over 25% of the UK's total wind energy portfolio. By comparison, Denmark currently has the second largest offshore portfolio, totalling 857MW, but has a very small development pipeline. Table 5 sets out operational capacity, projects underway and the future development programme.

Table 5: Outline UK Offshore Wind Programme

Current UK offshore status - Current at March 2012		
	Schemes	MW
Operational	19	2,110
Under construction	6	2,105
Approved and in planning	7	2,925
Pre-planning	1	1,200
Sub-total	33	8,340
Crown Estate Agreements comprising of:		
Round 3	9	32,215
Round 1 & 2 extensions	4	1,539
Scottish Territorial Waters	5	4,665
Demonstration Sites	4	190
Sub-total	22	38,609
Total	**55**	**46,949**

Source: Project database, The Crown Estate, current March 2012

Whilst the overall pipeline implied by Round 3 and the Scottish Territorial Waters is very large, the UK's current consented capacity – 2.9GW represents a small proportion of the European total. EWEA claim that the UK's share of consented capacity is 5%, based on the dataset reported in the EWEA 2011 statistics digest.[13] Germany and the Netherlands are reported to have a larger consented pipeline, although our understanding is that additional local consents are required before offshore work can commence. Given the UK's constrained consented pipeline, there is the possibility that next phase of large-scale offshore development could occur off mainland Europe, attracting investment away from the UK.

This issue is relevant to the study because uncertainty over pipeline is one of the biggest barriers to encouraging investment, which will affect the competition and vertical collaboration levers. Lack of certainty of sustained progress in the conversion of the project pipeline into development has reduced the urgency of investment into the UK offshore wind industry. Only Siemens and Vestas have submitted planning applications for manufacturing plants, and whilst Gamesa confirmed their selection of a site in Leith in spring 2012, no planning submission has yet been made.

Competed developments

Operating fields which contribute to the UK's offshore resource are summarised in Table 6 below. UK projects include six of the largest wind farms installed so far. All other large schemes are located in the North Sea. Details of five large European projects are summarised in Table 7.

[13] EWEA, European offshore wind industry 2011 key trends and statistics, January 2012

Table 6: Operational Wind Farms in UK Territorial Waters.

Date	Site	Size (MW)	Owner	Turbine
December 2000	Blyth	4	E.on	2 x Vestas V66
December 2003	North Hoyle	60	NWP Offshore	30 x Vestas 2 MW
March 2004	Scroby Sands	60	E.on	30 x Vestas 2 MW
October 2005	Kentish Flats	90	Vattenfall	30 x Vestas 3 MW
July 2006	Barrow	90	DONG/Centrica	30 x Vestas V90
June 2007	Beatrice	10	SSE	2 x Repower 5 MW
October 2007	Burbo Bank	90	DONG	25 x Siemens 3.6
March 2009	**Lynn & Inner Dowsing**	**194.4**	**Centrica**	**54 x Siemens 3.6**
December 2009	Rhyl Flats	90	RWE Npower	25 x Siemens 3.6
April 2010	**Robin Rigg**	**180**	**E.on**	**60 x Vestas V90**
April 2010	**Gunfleet I & II**	**172.8**	**Dong**	**48 x Siemens 3.6**
September 2010	**Thanet**	**300**	**Vattenfall**	**100 x Vestas V90**
July 2011	**Walney I**	**183.6**	**DONG/SSE/Ampere**	**51 x Siemens 3.6**
February 2012	**Walney II**	**183.6**	**DONG/SSE/Ampere**	**51 x Siemens 3.6**
February 2012	**Ormonde**	**150**	**Vattenfall**	**30 x Repower 5 MW**

Source: EC Harris and others. Large sites are highlighted.

Table 7: Large schemes in European Waters

Date	Site	Size (MW)	Owner	Turbine
2002	Horns Rev I – Denmark	160	DONG/Pension Denmark	80 x Vestas V80
2003	Nystod – Denmark	166	DONG/Pension Denmark	72 x Siemens 2.3
2009	Horn Rev II – Denmark	209	DONG	91 x Siemens 2.3
2010	Bligh Bank – Belgium	165	Belwind Consortium	55 x Vestas V90
2010	Rodsand II – Denmark	207	DONG/Centrica	90 X Siemens 2.3

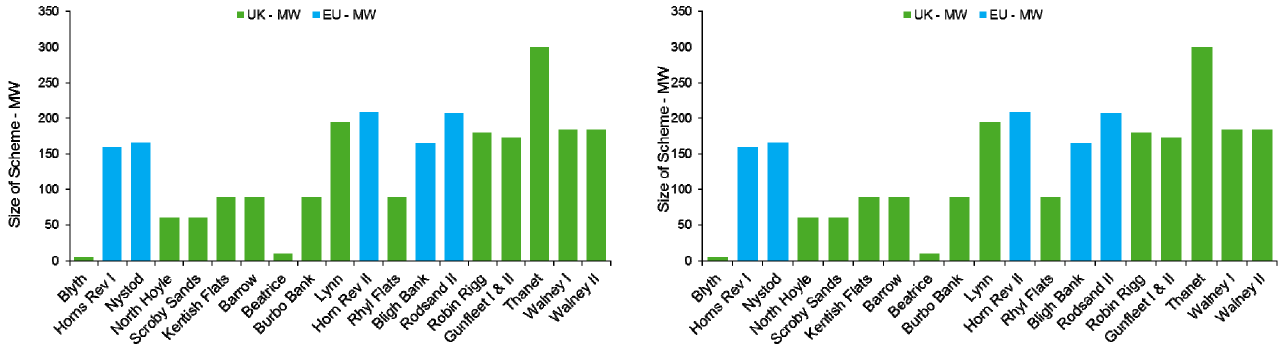
Source: EC Harris and others

Table 5 and Table 6 show that the offshore market is currently dominated by OEMs, Siemens and Vestas. Market share is examined in more detail in section 2.5. In early projects, UK schemes typically featured larger 3MW + turbines. These schemes are currently being built with similar capacity to equivalent European fields (see Figure 9 below) and have benefitted from economies of scale associated with the use of larger turbines. The chart to the left plots projects by capacity, showing that recent UK projects plotted in green are of a similar total size to the larger European developments scheduled in Table 6. The chart to the right, plotting numbers of turbines indicates that this capacity is being delivered with fewer, larger turbines.

Use of larger turbines reduces the number of installation operations required to deliver a given capacity. With 5MW turbines now being adopted on a number of German and Belgian schemes, further installation efficiencies will be secured. It should be noted however that at present, only one major UK project, Ormonde has specified the latest generation of turbines.

The implication of this analysis is that stories that feature the faster adoption of larger turbines will secure benefits from the reduction in volume of installation operations. This factor is examined in greater detail in section 2.7, which examines the supply/demand balance. Benefits of early technological development need to be balanced against the need to secure return on investment, and the potential benefits of horizontal cooperation based on greater standardisation.

Figure 9: Project Capacity and Number of Turbines, UK and Major European offshore wind farms.



Source EC Harris and others

Development Pipeline

Table 8 sets out the current development pipeline in European Offshore waters, including UK schemes. The total potential installed capacity is 3.3GW. This pipeline will have been completed by 2013. As discussed in connection with Table 5, there is only 2.2GW of new capacity currently in the UK consenting process that can readily be added to this pipeline.

Table 8: European Offshore Wind farms under construction – 2012.

Commencement Date	Site	Size (MW)	Developer	Proposed Turbine
May 2009	Greater Gabbard	504	SSE/RWE	140 x Siemens 3.6
March 2010	Sheringham Shoal	317	Statoil/Statkraft	88 x Siemens 3.6
April 2010	Lincs	270	Centrica/DONG/Siemens	75 x Siemens 3.6
Summer 2010	Bard – Germany	400	Enovos	80 x Bard 5MW
February 2011	London Array I	630	DONG/E.on/Masdar	175 x Siemens 3.6
Summer 2011	Borkum - Germany	400	Trianel	80 * Areva 5 MW
April 2011	Thortonbank Phase II - Belgium	185	Vattenfall	30 x Repower 6M
Summer 2012	Thortonbank Phase III - Belgium	100	Vattenfall	30 x Repower 6M
January 2012	Anholt – Denmark	400	DONG	111 x Siemens 3.6
January 2012	Teeside	62	EDF	27 x Siemens 3.6
January 2012	Gwynt Y Mor	567	RWE/Seimens/Stadtwerke Munchen	160 x Siemens 3.6
2012	West of Dudden Sands	389	Scottish Power Renewables/DONG	108 x Siemens 3.6

Source: EC Harris and others

As described previously, short term constraints on the UK consented project pipeline mean that there is potential for the focus of development to transfer to other European markets, should consents be obtained more readily. The implications for this study are that the UK may not retain its position as the leading European market for offshore wind, prior to volumes increasing after FID 2014.

Outside of the UK, EU member states have announced plans for over 100GW of offshore wind capacity, of which 18GW has already been consented[14]. The EWEA anticipates up to 40GW of installed capacity being installed by 2020, with a potential additional 110GW being built between 2020 and 2030.

Offshore markets in other regions are also anticipated to expand, according to EWEA's 2011 report, Wind in our Sails[15]. For example the US Bureau of Offshore Energy Management, Regulation and Enforcement has identified four mid-Atlantic areas for potential development. Progress is being made with regard to the transmission infrastructure, and some 2.3GW of capacity across nine sites is currently being considered – equivalent at current rates of installation to 2.5 years of growth in European off-shore capacity.

Similarly the Chinese market share is expected to increase over the next decade. China claims to have 750GW of exploitable offshore wind resource, and the current Five Year plan (launched in 2011) calls for 5GW to be deployed by 2015, and 30 GW by 2020. With a good resource of near-shore sites in proximity to major sources of energy demand, it is likely that China will make significant progress in this sector.

Summary

The pipeline described in Table 7 is the first evidence of the increasing diversification of the turbine manufacturing base, with a significant reduction in Vestas' and Siemens' market share being driven by new entrants with larger turbines aimed at the UK Round 3 and German North Sea markets. Several trends are apparent from the data presented in section 2.3;

- The UK is currently a key European offshore wind market in terms of existing capacity and rates of installation. It has the potential to continue to be a dominant market if the potential of Round 3 is realised. However the industry remains immature – with installation rates in excess of 300MW only having been delivered since 2007. Whilst the UK had 52% of the operational market, and three-quarters of installed capacity in 2010, future growth depends on the creation of a substantial pipeline of consents and availability of finance and capacity.

- There will be a hiatus in UK deployment prior to the ramp up of activity under Round 3. The acceleration in the consenting process for Round 3 sites in 2012 will be crucial in triggering enabling investment in manufacturing capacity, larger vessels and delivery capability, as well as on-shore grid connections.

- Technology choice has been limited until very recently. The core Vestas and Siemens technologies have been the only options considered for the majority of developments in the last ten years. Projects now under construction feature three new market entrants featuring 5MW large scale turbine technology aimed at Round 3 and Northern North Sea projects. New market entrants have moved from development on a demonstration scale, for full scale implementation. Areva and Repower turbines for example are the closest the market has yet come to delivering purpose-built offshore wind turbines, as opposed to marinised variants of onshore models. .

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[14] EWEA, European offshore wind industry, 2011, ibid

[15] EWEA, Wind in our Sales, 2011, ibid

2.4 Programme considerations – case study: Thanet

Thanet is one of the largest operational wind farms in the world, and is one of only three Round 2 sites to reach operational status. It is a useful case study source for details of best practice project programming. Table 9 sets out key project dates and durations.

Table 9: Thanet Wind Farm development programme

Phase of Development	Phase Completed	Phase Duration (months)
Lease awarded	Dec 2003	
Consents applied for	Nov 2005	23 months
Project consent	Dec 2006	13 months
Offshore works commence	Oct 2007	10 months
First foundation installed	Mar 2009	17 months
First turbine installed	Dec 2009	9 months
Site fully connected	Sep 2010	9 months

Source: EC Harris and others

As can be seen from the above, the preparation of studies and environmental statements took almost two years from the date of contract award, very similar to the timescales seen for other offshore projects. The consenting process itself took a further year, also similar to that seen for other projects. The London Array project which was awarded a lease and applied for consents around the same time as Thanet has experienced significant delays in securing consent for the onshore substation and is only now commencing turbine installation.

The time taken for an offshore wind project from lease award and operation can be broken down into three phases;

— Consenting – 3 years: This period involves the preparation of the necessary studies, compilation of the application documents, public exhibitions of proposals, submission and consideration by the relevant authorising bodies. It is too early to see what impacts the transfer of powers from the IPC to a National Infrastructure Directorate from 31st March 2012 might have on the nature and timing of this element of the process. Under the new structure, final decisions will be taken by the relevant Secretary of State – increasing accountability, but also raising political stakes associated with each consent. The approval stage adds a further three months to the planning timescale.

— Contracting and Financing: This is perhaps the most elastic part of the process with fast-track projects such as Thanet moving from consent to a construction start inside a year. Lynn and Inner Dowsing took nearly three years to commence construction post consent. Given the relatively low numbers of projects built to date, and the significantly increased scale of more recent projects, it is too early to suggest typical timescales at this stage.

— Construction works – typically 3-4 years for 300 to 500MW project, including 3 seasons of off-shore working, typically between April/May and December. Construction durations re relatively consistent, as can be seen from the representative sample of current and completed UK projects in Table 10, which sets out key construction dates.

Table 10: Comparison of Construction and Installation Programmes – UK Offshore Wind

Task\Site	London Array (175 WTG)	Thanet (100 WTG)	Gwynt Y Mor (160 WTG)	Lynn and Inner Dowsing (27 WTG)
Onshore works start	March 2010	Oct 2007	Oct 2010	October 2006
Offshore works start	March 2011	March 2009	Q2 2012	April 2007
1st turbine installation	Q1 2012	Dec 2009	Apr 2013	March 2008
Completion	Q2 2013	Sep 2010	Jul 2014	March 2009
Overall duration	3 years	3 years	3¾ years	2½ years

Source: EC Harris and others

Installation rates are improving as larger projects provide teams with opportunities to benefit from learning curve effects. Installation of 51 turbines on the recently completed Walney II project was completed in 9 months – down from 10 months for the first phase, which also has 51 turbines.

2.5 Analysis of Key Players and potential entrants

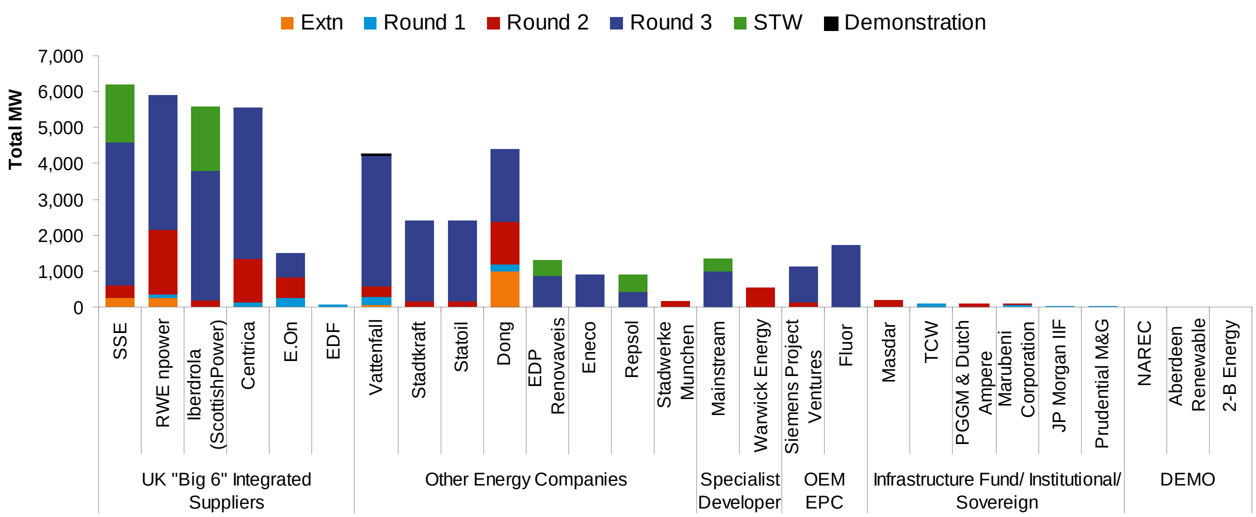
This section of the report provides a detailed overview of current capacity in the UK and European Offshore Wind industry. It provides the background to the comparison of baseline capacity and demand from the stories.

Tier 0: Owner/Developers

Overview

Figure 10 summarises active developers and joint ventures currently involved in the UK Offshore wind market, based on Crown Estate data current in March 2012.

Figure 10. UK Developer Portfolios



Source: Crown Estate

The dynamics of the developer market is examined in detail in finance work stream report by PWC, and this section should be read in conjunction with that report.

The characteristics of the key developer groups are as follows:

— UK 'big-6' utilities. Most of these businesses are subsidiaries owned by European-based global utilities conglomerates such as RWE, E.on, EDF and Iberdrola. Centrica is listed on the London Stock Exchange. The big six have invested £8 billion per annum in UK energy infrastructure in recent years[16]. Centrica and E.on are both significant presences in the market – as direct developers and joint venture partners. RWE have a JV interest in 4 operational schemes, together with 2 projects on site.

— European utility companies. By contrast with the big 6, these companies have no strategic business links to energy supply businesses in the UK. Whilst, companies such as Dong and Vattenfall are major players in the UK offshore wind market they are ultimately footloose in terms of their choice of market. Dong is currently the UK's leading developer/investor, and is involved in 7 operational farms, 2 farms under construction and a pipeline of 4 others. DONG entered into a JV with Centrica in March 2012 – Dong's second commitment to in Round 3 investment. As can

[16] Royal Academy of Engineering, "Making Green Growth Real", June 2011

be seen from Figure 10, companies such as Stadtkraft currently have a small exposure to the UK but a larger potential involvement in Round 3.

- The other four developer segments currently have a low profile but are set to become more significant in later rounds:
  - Developers such as Mainstream are likely to bring in JV partners once a consent is obtained;
  - OEM/EPC participants such as Siemens have the option to agree supply frameworks with developers as well as participating as JV partners;
  - Oil and gas businesses, such as the state-owned Statoil; and
  - Funds and institutional investors – an increasingly active segment in the European market. New entrants including Belwind, Enervos and Trianel illustrate trends with respect to developer and funder participation in the offshore market.
    - Trianel is the lead developer of the Borkum project which has over 30 shareholding JV partners. Funding for the Trianel development came mainly from the European Investment Bank (EIB) and State Bank of North Rhine-Westphalia. A club of commercial banks were also involved in the funding.
    - Belwind is being developed by a consortium of private and public investors including retailer Colruyt Group, SHV holdings, PMV, the Flemish State-owned investment arm and Rabo Project Equity. Belwind was the first wind project to benefit from EIB project funding.
    - Meerwind is Germany's largest fully funded offshore wind project being undertaken by WindMW, a company that is majority owned by US Private Equity Firm, Blackstone. Meerwind is Germany's first fully privately financed offshore wind project. Neither Belwind nor Meerwind has direct input from a Utility Company.

Looking at wider trends in the UK market, there is currently limited evidence of the involvement of sovereign wealth funds in the financing of larger offshore schemes. MASDAR's acquisition of a 20% minority interest in the London Array project is a welcome development in this respect.

Dong Energy has also sold off shares of UK and European Wind Parks to Institutional Investors, including Danish and Dutch pension funds.

Private equity is also starting to play a role as evidenced by the sale by Centrica of 50% of its equity interest in the Lynn and Inner Dowsing wind farms to TCW Energy, a subsidiary of Societie General, and the creation of a JV for the long term operation of the Wash portfolio of offshore projects. Blackstone has participated as the sponsor of Meerwind. Ampere's stake in the Dong Energy Walney scheme is an example of the involvement of a fund as an equity partner in development.

The involvement of OEMs and installation contractors as development partners, either as formal members of a JV, or as development partners is creating opportunities for vertical collaboration. RWE for example have a formal JV with Siemens on Gwynt Y Mor, and BARD has teamed up with minority JV partner Enovos on the BARD Europe 1 scheme. Dong has used Siemens on all but one of their schemes. Other examples of increasing integration of developer and supply chain include joint ownership by Dong Energy and Siemens of A2Sea – the specialist vessel owner, and the recently announced alliance agreement between Gamesa and Iberdrola-owned Scottish Power.

Developer baseline – Implications

The European developer market is particularly diverse. The current five major European wind-farms described in Table 7 are being delivered by Dong, Vattenfall, and new entrants BARD and Triane. By contrast, the UK has only seven major players who are active participants in Joint Ventures.

In addition to existing participants with interests in Round 3, new development participants that will potentially enter the UK market in connection with Round 3 and Scottish Territorial Waters licences include:

- EDP Renovaveis (Portugal)
- Mainstream (Ireland). Mainstream are likely to sell on to development partners once consents are obtained.

— RES (UK)

— Eneco New Energy (Netherlands)

— Fluor (US) (previously acting solely as EPC contractor)

— Repsol (Spain)

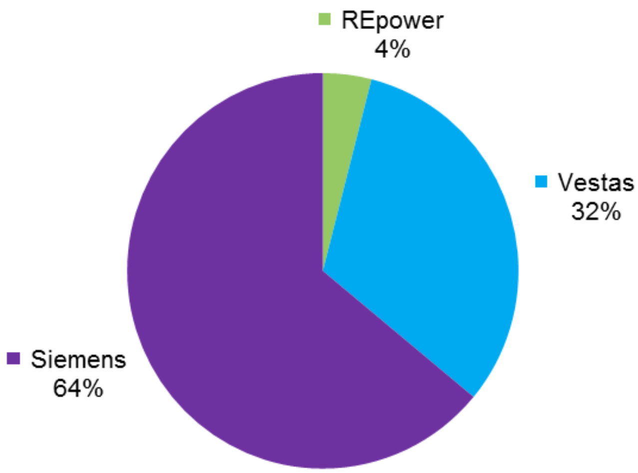
Tier 1: Wind Turbine Manufacturers

Wind Turbine manufacturers are also termed Original Equipment manufacturers (OEM) in this report.

Further discussion of the Wind Turbine OEM 2nd tier supply chain including blade manufacturers and gearboxes is included in section 4, detailing cost reduction levers.

Siemens is currently the main provider of turbines in the UK – with a market share of 64%. The state of current market is set out in Figure 11 below:

Figure 11: UK offshore turbine market share



Source: EC Harris based on data for 25 UK wind farms where the turbine manufacturer was stated.

Analysis of data sourced from GWEC's market reports published in 2009 and 2010 [17] provides early evidence of the commencement of diversification of the turbine market, showing the entry of four manufacturers into the market. RePower, WinWind and Areva can all now demonstrate completed and commissioned wind parks in Europe.

The dominance of Siemens extends into global markets. Vestas produced and shipped just over 2,000 turbines (onshore and offshore) in 2010, and REpower supplied turbines for its first contract in Sweden. In the same period, Siemens produced over 9000 turbines (onshore and offshore). Most of these turbines are on-shore variants. With wind turbine volumes of this scale, both Siemens and Vestas support substantial R&D investment – demonstrated in the analysis of margins and overhead described in later in this section.

Revenue investment in research and development among leading turbine manufacturers and new competitors is reflected in the extent of new product development in the sector. Development plans for 51 new turbine offshore models have been announced

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[17] GWEC, Global Wind Report, 2009 and 2010

by 41 companies in the past 2 and half years[18] EWEA report that between 4 and 12 new offshore turbine models will be made commercially available over the next 10 years[19].

Future OEM development and investment trends

New players entering the market include Alstom, XEMC Darwind, Mitsubishi and Samsung. Based on most of the 'stories' and developer expectation, the market will develop around turbines in the 5-7MW class for most of the coming decade. These new machines are likely to be among the first generation of specialist offshore machines, designed exclusively for maritime use. Given the scale of the new turbines, new coastal manufacturing hubs will need to be created that provide for the scale of blade, turbine and tower production required by the new designs. Only Siemens and Vestas have so far confirmed chosen manufacturing locations in the UK.

Announcements have been made by a number of OEMs with regards to UK and wider European investment as follows:

- Siemens. Currently controls the bulk of the offshore market. Siemens submitted plans for a £210m investment in Hull's Alexandra Dock in December 2011. It is currently anticipated that Green Port Hull will be operational by 2014. The plant will manufacture 200 – 300 6MW turbines per annum and has a maximum annual capacity of 500 turbines per annum[20].

- Vestas. Took an option out on land in Sheerness in May 2011 and submitted a detailed planning application in January 2012 for a facility employing up to 2,000 people, assembling 7.5MW turbines. Construction could start in 2013. Subject to the size of the turbine order-book, the facility should be operational by 2015. Vestas have developed a suite of O&M products, including 10 year extendable agreements which guarantee high levels of availability.

- Alstom. Have developed a 6MW turbine aimed initially at French off-shore opportunities. A prototype is currently being tested on land prior to sea-testing in autumn 2012. Production will initially be based in France and is expected to commence in 2014. Alstom has an exclusive supply arrangement with the EDF-led Energies Nouvelles joint venture.

- Areva. Renewable energy is currently a small segment of Areva activity, contributing 1.6% of turnover in 2010. Areva has an order book of 250 units for their 5MW direct drive turbine solution.

- RePower. Wholly owned by Suzlon, who have recorded trading losses in 2009/10 and 2010/11. RePower made good margins during 2010/11 and increased capital investment by 45% to €72m. RePower has taken 100% control of its Power Blades JV. It has a memorandum of understanding representing a pipeline of 250 turbines for RWE.

- Samsung. Has confirmed plans for an investment of up to £100m in Scotland in a JV with David Brown Gear Systems for production of a 7MW offshore turbine; subject to satisfactory prototyping in UK conditions, further investment is expected to follow.

- Gamesa. Announced an alliance with Spanish-owned Scottish Power for 50% of a wind turbine pipeline totalling 3.8GW between 2013 and 2023. Most will be onshore turbines. Gamesa confirmed in March 2012 that its £150m investment in UK manufacturing capacity will be located in Leith.

- Mitsubishi. Is planning a 5 year, £100m investment in turbine R&D in Scotland, based on new technologies. The development may result in further investment in production capacity from 2015 onwards.

- General Electric. Announced plans in 2010 to invest £150m in productive capacity for large turbines based on gearless technology. No further details have been provided since the announcement was made.

- XEMC Darwind – XEMC Darwind is a Dutch/Chinese JV based in second generation direct drive permanent magnet technologies. In 2010 XEMC Darwind indicated an interest in a UK manufacturing location. An investment decision will be made in 2012 and will be determined partially by the availability of state support. XEMC Darwind installed prototype turbines in Europe and the Far East during summer 2011.

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[18] EWEA, European Offshore Wind Industry, 2012, ibid

[19] EWEA, Wind in our sails, 2011, ibid

[20] Details of planning consent reported by Winddaily.com, 27 February 2012

EWEA report that from FID it will take a new manufacturing facility four years to reach a production rate of 250MW/annum, five years to reach 500MW/annum, and eight years to reach 1GW/annum[21]. No final approvals have been made for manufacturing plant in the UK. Based on details available for the Siemens development, the level of investment likely to be required in each manufacturing plant will be in excess of £80 million.

Margins and allowances for overhead and risk – OEM case study

A key issue in the cost reduction pathways study is the need to understand the extent to which the proportion of cost attributable to margin and risk varies over time, so that this can be factored into the cost reduction levers. The cost baseline set out in Table 1 shows that risk allowances make a substantial and variable contribution to overall costs.

EC Harris has reviewed a number of cost studies published by EWEA (2009), UKERC (2010) and BWEA (2009). None of the studies reviewed includes a breakdown of the allocation of project risk, overhead and profit. Given the number of alliances that has been established in the European market over the past two to three years, developers are likely to have much greater transparency of their cost base, but this information has not been made available to the EC Harris team.

Most participants in the offshore wind supply are either privately owned or subsidiaries of larger companies, so it is difficult to isolate the profitability of wind-related business units, or to understand bidding strategies – in terms of risk allowances, overhead contribution and net profit. Wind turbine manufacturers are a key element of the supply chain from which some aspects of financial performance can be obtained. The following analysis is based on the segmentation used by organisations in their published accounts. It provides some indication of net margin and contribution, but not of bidding strategy.

Annual reports published by active turbine manufacturers indicates a sharp reduction in financial performance during 2010 as the onshore market in Europe and the US adjusted to the economic downturn and offshore programmes slowed down, as evidence in output data reported in Figure 5. In most instances offshore wind power is reported as part of a larger renewables business segment and the contribution cannot be isolated.

Table 11: Financial Performance of turbine manufacturers.

Task\Site	Siemens		Vestas		RePower		Areva	
	FY 2010/11		FY2010/11		FY2010/11		FY2009/10	
	€	%	€	%	€	%	€	%
Group Revenue	73,515		5,836		1,216		9,104	
Gross Margin	22,127	30.0	725	16.9	n/a		1,326	14.6
R&D expenditure	3,925	5.3	203	5.3	36.9	3.0	354	3.9
Operating expenditure	10297	14.0	560	13.9	132	10.8	1,497	16.4
Net Margin	6,321	8.6	(60)	(1)	84.5	6.9	(423)	(4.6)
Renewables Segment Revenue [1]	3,932	5.3					150	1.6
Renewables Segment Margin [2]	(2)	(0.05)					(122)	(81.3)

Source: Annual Reports

Notes:

1. Wind segment revenue: As percentage of Gross Revenue.

2. Wind segment margin: As percentage of segment revenue

The analysis in Table 11 sets out the recent financial performance of the major turbine manufacturers, including reported margins. The data is sourced from annual and interim statements. Reported gross margins range from 14.6% to 30% -

[21] EWEA, Wind in our Sails, 2011, ibid

indicating the diverse nature of parent companies. The tables describe the share of revenue attributable to the renewables segment. Vestas and RePower are specialist wind turbine businesses, although RePower is a business unit within the larger Suzlon Group

R&D expenditure for these businesses is significant – ranging from 3 to 5% of turnover. Operating expenditure ranges from 11 to 16% of turnover. As a result group margins for the profitable businesses – Siemens and RePower range from 7 to 8% - healthy but not particularly high margins. Vestas and Areva have both reported losses in the past FY.

Where a breakdown is available for the renewables segment of a business, margins are also analysed in the table. These are variable – ranging from marginal losses by Siemens and Vestas to an 81% loss by Areva. The wider Suzlon Group recorded a profit of 11.2% in FY 2010/11.

Table 12 sets out a further analysis of Siemens results of the energy business line to identify how margins in the renewable energy business have changed over time. The segment includes onshore wind and a solar business, so the change cannot be directly attributed to offshore wind.

Table 12: Comparison of Energy Sector Margins, Siemens 1st Quarter interim statements, 2008 to 2012

	1Q2008	1Q2009	1Q2010	1Q2011	1Q2012	Average
Fossil Fuel	1.3%	12.2%	17.8%	19.3%	22.2%	14.6%
Renewable Energy	12.5%	14.2%	6.1%	4.2%	-5.1%	6.4%
Oil and gas	8.0%	10.1%	12.6%	10.2%	7.3%	9.6%
Power transmission	10.0%	10.1%	12.9%	9.4%	-9.9%	6.5%

Source: EBITDA for Energy Sector only, Siemens interim statements.

This analysis of Siemens interim results for their renewable segment over the period 2008 to 2012 based on 1st quarter interim statements shows that the contribution to profitability of the renewables sector has declined over the period – delivering a progressively lower margin year on year. Quarterly results are inevitably more variable than full year results, and have been used so that the initial reporting from the first quarter of the current financial year can be included – Siemens are currently reporting a €48m loss. The sector includes the performance of the solar energy business as well as offshore wind.

The analysis shows that all sub-segments in the energy sector have delivered margins of 10-12%+ over the period. The best performer is fossil fuels, which is likely to have benefitted from an acceleration of activity related to high oil and gas prices. By contrast, the performance of renewables has been weakening since 1Q2009.

Supporting evidence of diminishing performance comes from Vestas, who in their 2011 FY reporting have shifted their long-term margin target from 15% to 'high single figure' in the face of tough trading conditions in key markets. The senior management team at Vestas has recently undergone significant change as a result of poor business performance in 2011.

This evidence of variability in margins in the wind-turbine industry supports the case for the competition-based cost reduction levers discussed in section 3.

Evidence of contraction in the supply chain

Due to the downturn in global demand for wind turbines, Vestas announced manufacturing capacity reductions during 2011. Further announcements with regards to the relocation of manufacturing capacity into non-European markets were made in February 2012. We have not found evidence of other OEMs reducing their productive capacity in response to the current downturn. However, GE is reported to have scaled down their investment in the Norwegian offshore specialist ScanWind.[22]

OEMs are understood to be preparing for the non-renewal of Production Tax Credits in the US in December 2012. Should the decision go against renewal, it is expected to have notable, adverse consequences for the wind sector, which could affect investment decisions of potential UK market participants such as General Electric.

[22] Bloomberg, 9 Spetember 2011

Implications for supply chain development.

Major steps have been taken to build the infrastructure for post Round 2 offshore wind manufacturing capacity. The most significant developments have occurred in Europe with the shift into production of purpose-designed offshore turbines by OEMs including Areva and RePower. The Siemens SWT 3.6 remains the most commonly used turbine technology – creating potential benefits for horizontal integration of installation and O&M processes.

Based on investment plans announced by global players including GE, Samsung and Mitsubishi to invest in UK-based capacity, and the advanced state of development of initiatives by Siemens and Vestas, the UK could have significant manufacturing capacity in place or under development by 2015. EWEA report forecasts of annual capacity of between 6 and 7GW pa by 2015[23]. However, no manufacturer has confirmed FID on UK investment, and planned investment appears to be conditional on a confirmed minimum market size of around 2GW per year, for existing manufacturers and new entrants alike. Any new capacity will be focused on all-new technology both in terms of unit size and technology employed – e.g. 5MW + turbines with gearless drive. The upfront costs of R&D and facility development will need to be recovered. As indicated in the analysis of financial reports, R&D investments by turbine specialists are extensive. Despite extensive research, we have not been able to isolate the total R&D costs of the development of a new wind turbine family, but as an indication of the scale of investment required, the capital costs of the Dong Energy prototype test of the Vestas 164 7MW turbine is reported as being over €32m.[24]. Clearly greater certainty with regards to the medium term pipeline will strengthen the case for investment.

Tier 1: Foundation manufacturers

The foundation market has traditionally been dominated by the monopile sector. 2011 saw significant growth in jacket and tripod solutions as 5MW projects in deeper water such as Ormonde and BARD proceeded to construction**.**

Monopile manufacturers

Monopile has been the support structure technology adopted on most shallow water wind parks installed to date. According to data compiled by AWS Truewind, published in 2009,[25] monopole bases have been used on over 70% of completed projects, and even with the new wave of deeper water projects coming on stream, continue to dominate the market. Monopiles had 62% of the market in 2011 according to EWEA.[26]

The size of monopiles is constrained by the physical capacity of specialist plate manufacturers and challenges associated with the welding of very thick steel plate. Established manufacturers are also involved in the production of transition pieces on which the turbine tower is fixed. Main players in the sector include:

— MT Hojgaard – have a track record of over 600 foundations and claim to have installed one third of all offshore foundations. Services are typically provided on a design and build basis – with fabrication undertaken by specialist sub-contractors.

— SIF – have been involved in the Kentish Flats, Beatrice and Bard Offshore 1 projects. Their workload includes monopiles, transition pieces and jackets. SIF are a private company with a background in Oil and Gas.;

— Smulders – have produced over 600 monopile foundations and have capacity to manufacture 200 monopiles per annum. Smulders is a private company with a background in steel bridge and marine structures.

— Bladt Industries – have extensive monopile experience on projects ranging from Horns Rev II and the London Array. Bladt have the contract for Gwynt Y Mor in a joint venture with specialist pipe fabricators EEW. Bladt also have a jackets business serving sub-stations and oil and gas

— Ambau – major monopole and tripod contracts on Meerwind and MEG 1 offshore. Ambau is privately owned and has capacity for 450 foundations per annum.

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[23] EWEA, Wind in our Sails, 2011, ibid

[24] Reuters, Dong energy to Test Vestas 7MW turbine, 27 October 2011

[25] AWS Truewind, “Offshore Wind Technology Overview”, 2009

[26] EWEA, European Offshore Wind Industry, 2012, ibid

— Mabey Bridge is a UK owned tower and monopile foundation manufacturer. It recently completed a £38m investment in additional capacity. It has a preferred supplier arrangement with RePower – initially focused on towers for the on-shore market.

— TAG energy solutions. TAG is a recent UK-based market entrant that has completed a £20m investment in new production capacity and has the capability to fabricate 100,000 tonnes pa of monopiles suitable for Round 2, Round 2 extension and some Round 3 projects.

— Skykon. Skykon was bought out of administration in 2011 by a consortium of utility company, SSE and restructuring specialist, Marsh.

This analysis shows that existing capacity for monopile production in Europe is around 1,000 per annum – double current demand levels, and therefore likely to be sufficient to accommodate demand from the UK and European markets. Refer to section 2.7 for a discussion on future supply and demand dynamics. Most participants are medium sized privately owned specialist engineers. Some participants such as TAG are likely to move into Jacket Fabrication. The Greater Gabbard project has also demonstrated that monopiles can be sourced from low cost locations – in this case from Chinese fabricator, ZPMC. Looking forward, out-of-region suppliers such as ZPMC demonstrate the potential to provide surplus capacity in response to increased demand.

Jacket manufacturers

Demand for jacket foundations has so far been limited, with most projects being delivered using more conventional monopile foundations suitable for shallow waters. However, the market is growing, and according to EWEA,[27] jackets made up 20% of the installation market in 2011. So far only two major projects have been completed – Ormonde and Thornton Bank II. Jacket specialists also have a key niche in the provision of supports for larger topside structures such as substations.

Jacket structures have been used on substation platforms using techniques developed in offshore Oil and Gas. Large, one-off jackets used for platforms are bespoke and take at least 18 months to design and fabricate[28]. As projects move into deeper waters, mass–production techniques will be needed. Based on projects commissioned to date, there is limited demand or experience in this sector – mostly related to oil and gas. However, demand is likely to ramp up rapidly as larger turbine technologies become established. Principal players in the European jacket supply chain include:

— Bifab – Bruntisland Ltd. Bifab has 3 sites and capacity for 150 jackets per annum. It made a £14m investment in its East Fife facility in 2010. Bifab aims for a 50/50 split between offshore oil and gas and offshore wind. Bifab is privately owned and has completed three offshore projects including 30 jackets on the Ormonde project. SSE took a 15% stake in Bifab in April 2010.

— OWEC are a specialist jacket designer, responsible for the design of the jackets used on the Ormonde project. A 50% share of OWEC has been purchased by Singapore-based KV Ventus and additional investment has been made by current owners.

— Hereema – Hereema has UK and European facilities. With a background in oil and gas, most foundation work in the offshore wind sector has been on large sub-station top-sides – including recent structures for Sheringham Shoals.

— Harland and Woolf – H&W has provided logistics services for offshore wind projects in the Irish Sea. It has secured a jacket fabrication contract for a Transformer platform on Bard 1. The H&W yard is located adjacent to the fabrication/logistics facility to be developed by Dong in Belfast.

— Smulders and Bladt - Monopile fabricators, are also developing jacket capacity. Bladt have fabricated the innovative ‘twisted’ jacket used on the Hornsea metrological mast station. Smulders have manufactured 24 OWEC designed jackets on Thornton Bank phase II.

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[27] EWEA, European Offshore Wind Industry, 2012, ibid

[28] RWE’s contract with Bi-Fab for sub-station jacket foundations at Gwynt Y Mor, based on a proven design, is based on an 18 month programme.

— TAG – Teesside Alliance Group – currently focused on monopile manufacture but has capability to switch to jacket foundations. Current capacity of 50 pa could increase to 100 per annum with planned investment.

— Aker Verdal – major offshore oil and gas jacket fabrication specialist. Aker Verdal has tripod and jacket foundation EPC contracts for Areva and Nordsee Ost.

The UK has a leading position in the jacket manufacture market related to the Oil and Gas sector. There are at least three other jacket fabricators including A&P, OGN, and Shepherd that could enter the market. It should be noted however that offshore specialist fabricator McNulty recently entered administration.

The UK also has the necessary steel plate and section manufacturing base, with Tata Steel in North-East England having a specialist manufacturing capacity. Tata has an annual manufacturing capacity of 200,000 tonnes and a specialist tube fabrication supply chain.

Jacket capacity currently exceeds demand but will need to ramp up prior to 2015 to meet projected demand. The only publicly announced example of preparatory investment is by oil and gas specialist OGN, which is investing £50m in a 36,000m^2 plant on Wearside which will come into service in 2013, with a capacity of 50 – 100 jacket foundations per year.

Gravity foundation producers some small alterations

Gravity foundations are common in the oil and gas industry. They are a relatively small market in offshore wind but have the potential to be less resource constrained in terms of specialist fabrication skills, and less vulnerable to fluctuations in global commodity prices. Initial moves by very large contractors into the gravity based market should create significant additional capacity backed by the ability to invest off balance sheet. Examples of recent entrants include:

— Strabag – entered the off shore market in 2009. Claims to have a capacity of 100 foundations per year based on a yard in Cuxhaven, and a pipeline of 400 to 1,000 units. Strabag is one of Europe's top 10 contractors with a turnover of €12.4bn in 2010.

— Gravitas – consortium of Hochtief, Costain and Arup – no project appointments so far. Hochtief is Europe's 3rd largest contractor.

— Sea Tower MT Hojgaard joint venture. Produce "Cranefree" foundations. Joint venture established in November 2011, with MT Hojgaard providing an EPCI-based service.

— Vinci Freyssinet offshore wind joint venture. Established in 2011 to implement the Gravity Based Foundation concept developed by Gifford, BMT Nigel Gee and Freyssinet as part of the Carbon Trust Offshore Wind Accelerator Programme.

Foundations - Summary

There is substantial capacity to deal with current levels of offshore activity. Contracts currently being let are some of the largest secured in the segment. Current players have made incremental investment to increase capacity. There are a number of potential new players who could enter the market, particularly in the jacket segment, although little investment has so far been committed in dedicated capacity. Both monopile and jacket manufacture are highly specialist undertakings, creating barriers to entry for new participants. Due to the size and weight of monopile foundations, manufacture close to site is preferable. Elements of jackets can be prefabricated, although final assembly also needs to take place close to site. Whilst there is plenty of monopile capacity, as the industry transitions to deeper waters and larger turbines, the ramping up of jacket capacity prior to 2015/6 will depend on further investment from existing participants in oil and gas markets. Assuming that the technology is adopted, the entry of gravity base consortia into the market will further diversify the supply chain.

Tier 1: Installation specialists

There are a range of options for the management of installations, depending on the degree to which the developer seeks to allocate risk to construction partners and the extent to which the developer is able to resource project management. Installation is perhaps the most diverse aspect of the second tier of the offshore wind supply chain, with management capabilities being provided by a range of organisations including specialist construction managers, fabricator-engineers and installers. These organisations manage projects under a range of contractual arrangements.

The tasks that need to be undertaken as part of the installation are as follows:

— Monopile/pre-pile installation (for jacket foundations)

— Transition piece installation

— Sub-station pre-pile and jacket installation

— Balance of plant installation

— Scour protection

— Vessel provision

— Transport of monopiles/jackets from quayside

— Quayside logistical support

Under a multi-contract arrangement, these activities could be undertaken by individual contractors and suppliers, managed directly by the developer. Under a bundled or mini-EPC contract these activities are typically managed by an installation contractor.

The services provided by an installation contractor generally include the procurement and management of the second-tier supply chain, logistics and the coordination and management of interfaces. Most of the work is undertaken by specialist contractors, but the single point of responsibility is provided by the installation contractor

Turbine installation services are typically provided by specialists, including vessel operators, employed directly by the OEM . Even where a bundled contract is in place, turbine installation will be generally be undertaken independently rather than as part of the scope of the installation contract. Turbine installation by the EPC contractor was identified as a cost saving opportunity by one vessel operator during the workshop programme.

Contractual Arrangements

The principal contractual arrangements under which installation is managed are summarised for clarity below:

EPC contractors
Over 10 years of European offshore wind development, there have been very few examples of the award of complete or nearly complete EPC contracts. The only examples of a complete EPC contract for all plant and services have been delivered by Vestas/KBR and Vestas. Full EPC arrangements are perceived to be no more effective in ensuring project outcomes than alternative multi contract or multiple mini EPC package arrangements. Mini-EPC arrangements, where a contractor takes responsibility for foundations and balance of plant installation have become more common. Fluor is currently delivering the Greater Gabbard project using an EPC for a SSE/RWE JV. The project has been subject to technical and contractual challenges. Minor change DONE

Main package/mini-EPC contractors
The supply chain includes major construction companies such as MT Hojgaard, Van Oord, Hochtief, ABJV, and Ballast Nedam, who will bring together supply and installation contracts based on their own internal resources and major subcontracts. To date none of these companies have included turbine supply within the scope of the packages that they offer. As these companies do not offer a full ‘turnkey’ solution, the option is termed mini-EPC.

Package lead contractors
The award of lead contractor positions for parts of the supply/installation work for offshore wind farms is more common under a multi-contract approach. This trend is likely to grow as developer purchasing choice over turbines etc increases.

Installation Package contractors
Some installation contractors are willing to provide a full installation-only service covering the majority of, or all of the installation scope including foundations, scour protection, turbines, cables, and offshore substation. This includes companies such as MPI, Van Oord, Seajacks, and GeoSea. These packages exclude the fabrication of monopiles, transition pieces etc.

Installation Contractor Services

Examples of the services offered by specific contractors are as follows:

Van Oord
Van Oord is a privately owned marine contractor specialising in marine engineering, land reclamation and offshore energy projects. On a turnover basis, Van Oord is ranked 51st in a 2011 ranking of European Contractors and House builders.

Van Oord delivered a mini-EPC contract for sixty foundations and Balance of Plant on Princess Amalia (2007). This excluded the supply and installation of the wind turbines. Van Oord was also awarded a mini-EPC contract for Belwind (2010) covering the construction of the foundation of 55 wind turbines, Balance of Plant and placement of 55 turbines. The turbines were supplied separately by Vestas.

Van Oord is contracted to deliver installation and balance of plant services on the Teesside Wind Farm for EDF, completing in 2012.

Vestas
Vestas acted as an EPC contractor for the entire supply and installation process on early UK projects Scroby Sands and Kentish Flats. Other arrangements involving Vestas include:

— **Vestas / KBR 50/50 J.V.** Vestas and KBR formed a 50:50 joint venture and delivered a full EPC contract for the Barrow project in the UK. Barrow was completed in 2005.

— **Vestas Celtic Wind / Mayflower energy.** Vestas and Mayflower Energy formed a joint venture and delivered a full EPC contract for the North Hoyle project in 2003.

Vestas continue to manage turbine installation on some of their manufacture projects.

Fluor Energy
Fluor is one of the World's largest EPCM contractors, with turnover of $20.8bn in FY2010. Fluor is acting as the EPC contractor for the balance of plant work, including the installation of turbines, on Greater Gabbard. Turbines are being supplied by Siemens. Fluor has reported pre-tax charges totalling $403 million against Greater Gabbard in their 2010 and 2011 Annual Reports[29] . The project is subject to dispute with SSE/RWE with regards to the quality of welding on imported Monopiles[30].

Siemens
Siemens have managed turbine installations on some of their manufacture projects such as Burbo Bank.

MT Hogjaard
MT Hogjaard is Denmark's largest construction and Civil Engineering Contractor. On a turnover basis, they are ranked 67th in Europe.

MT Hogjaard has acted as the main contractor for the foundation bundle-only on the following UK projects: Burbo Bank, Gunfleet Sands, Rhyl Flats, Kentish Flats, Lynn, and Robin Rigg.

ABJV (Aarsleff Bilfinger Berger Joint Venture)
ABJV is a joint venture of two major contractors. Aarslef is ranked 107th in Europe by turnover, Bilfinger Berger is ranked 13th. The ABJV was established in 2004.

ABJV handled the entire foundation package at Nysted and is currently on site for the London Array and Dantysk. On completion, it will have delivered foundations for the five largest wind parks in the world. ABJV will also undertake turbine installation.

Ballast Nedam
Ballast Nedam (BN) is a European Civil Engineering Contractor. Turnover in 2010 was €1,578m. BN have undertaken foundation works on Walney, London Array and have secured contracts on Anholt. BN have a single specialist heavy lift vessel, the Svanen, which has been used for the installation of monopiles at some offshore projects. It has limited shallow water capabilities.

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[29] Reuters, 22nd February 2012

[30] Details of the dispute are summarised in SSE's interim results statement, November 2011.

The introduction of future installation capacity

Turbine installers

Turbine installation continues to be managed in most cases by turbine manufacturers. However, suppliers have withdrawn from an EPC model and have focused on the installation of turbines alone. However, with new turbine supplier capacity coming on stream, new installation models may evolve. Bard for example has adopted a vertically integrated route, operating their own Vessel, Windlift which is configured to handle large turbines and jacket foundations in deep waters. Other examples include RePower, which has contracted A2Sea as a second tier supplier. With significant additional capacity being introduced into the Vessels market, the installation management service offered by turbine suppliers is unlikely to be affected by resource constraint in the immediate future. However, the progressive introduction of larger turbines may result in demand for larger capacity vessels and higher capacity on-shore logistics services.

Foundation and balance of plant installers

The analysis in section 2.6 shoes that current capacity for the management of foundation installation on a mini-EPC basis is sufficient but is limited to a relatively small number of medium sized contractors. The players involved, Van Oord, MT Hogjaard, Ballast Nedam are significant mid-table players but may not necessarily have the resources or appetite to expand capacity to meet projected demand from 2015 onwards. Installation contractors delivering projects on a mini-EPC basis have a potentially important role, providing supply chain management, logistics and risk transfer services to developers. As the market grows, it is important that other large engineering businesses are attracted to provide these services.

As most of the actual installation work is undertaken by specialist contractors such as foundation fabricators and vessel operators, the technical barriers to entry for new installation contractors are low in comparison with other elements of the offshore wind supply chain. Contractors are likely to attracted to the market if some of the cost reduction levers discussed in section 3.1, asset growth, contract forms and management of uncontrollable risk are addressed to enable capacity to grow. Should this capacity not emerge, the effect could be to reduce the range of procurement options available to developers.

Although North Sea offshore is likely to have high levels of activity related to decommissioning as well as O&M, active participants including Amec, Stadtkraft, KBR, McDermott and Technip may introduce new capacity as the market grows. Technip for example have established an offshore wind business unit and have invested in sub-sea cable installation capability.

Tier 2 Vessel providers

Vessel providers are a key element of the installation supply chain. There is some vertical integration of vessel provision into the installation supply chain and most capacity is delivered by specialists. As the annual rate of turbine installation has increased, pressure rapidly increased on vessel operators to provide sufficient capacity to meet market needs. This pressure has been focused on a small group of leading contractors as a result of their proven track record and the availability of their specialist fleet.

There are currently 12 specialist installation vessels operating in European waters, and a larger number of jack-up barges used for a range of off-shore operations. There are 32 cable laying vessels of varying capability. Current capability in European waters is mostly focused on sub 5MW turbines – half of the current fleet has limitations with regards to larger turbines, jacket foundations, and to a lesser extent, deeper water in excess of 35m. Only 4 vessels owned by A2Sea, MPI and Bard are currently capable of dealing with larger turbines and foundations.

Vessels which are unable to lift turbines in excess of 5MW, monopiles or jackets in excess of 600-650 tonnes or operate in water in excess of 35m deep will be less able to support new technologies or deeper sites, and as a result can be considered to be technologically constrained. If the rapid adoption of large turbines takes place, then it is likely that further investment in capable vessels will be required. As a result of new vessels and technology, the bulk of the current fleet will be confined to delivering smaller 4MW turbines once newer, larger turbine solutions have secured a significant share of the market.

10 Vessels are scheduled to be delivered in 2012 and 2013.[31] All will have capability to deal with larger monopiles and turbines and waters up to 45m deep. Capacity to deal with larger jacket foundations will also be expanded. So far, vessels have tended to be single purpose, specialised vessels, often sourced from the Oil and Gas sector. Some industry experts believe that the new generation of multipurpose vessels will be a more efficient solution, while others believe that single-purpose specialist

[31] Source: Consultant, Mike Prowse

vessels, such as jack-up barges are more cost effective. In some cases, such as the installation of large jackets and sub-stations, specialist vessels remain the only option. Looking forward, wider adoption of floating gravity foundations should reduce aggregate demand for specialist installation vessels, as some of these technologies can be installed using standard tugs.

EWEA's report, Opening up Offshore[32] calculated that 12 installation vessels will be needed to deliver 40 GW of capacity by 2020. On the basis of investment decisions already made, a significant element of this fleet is already on line and may suffer from a short term surplus of supply ahead of growth in installation volumes from 2015 onwards. Given the global markets in which these vessels can operate, it is vital that European workload is in place to enable operators to secure a return on very large investments – typically €240m per vessel.

The main players in the market are:

— A2Sea – part owned by Dong and Siemens. Operates 4 vessels with a further vessel coming into service in 2013. A2Sea has installed 700 wind turbines and 300 foundations – equivalent to 70% of the offshore market. A2Sea has entered into a development JV with Teekay Corporation to convert bulk carriers into transport vessels for turbines. A2Sea's existing fleet is best suited to the installation of the current generation of turbines and foundations.

  DONG Energy placed its 29% shareholding in cable installation company CT Offshore into the A2SEA business in July 2010. In January 2012 A2Sea increased this shareholding to 67% giving it full control of a cable installation capability.

— MPI Offshore – owned by shipping services company Vroon. MPI has installed over 200 turbines and added two new high-capability vessels to the fleet in 2010/11. MPI introduced the world's first purpose built jack up vessel specifically focused on the offshore wind market, and has built up an extensive track record in both foundation and turbine installation. They have installed foundations or turbines on UK schemes with over 600MW capacity. MPI have added two larger new build installation vessels, to the fleet in 2011/12 - these vessels are now working on the London Array project. MPI has long term charter arrangements with Centrica and E.on. In addition to heavy lift installation, MPI also offer cable installation services and are a provider and operator of crew transfer vessels.

— Seajacks – recently acquired by Marubeni and Japanese Government Fund INCJ from Riverstone Holdings for a reported $850m[33]. Operates two vessels with a third coming on stream in 2012. Seajacks has focused on turbine installation, including Walney 1 and 2 for DONG Energy and Greater Gabbard for Fluor. They have recently won the Meerwind project which includes foundation installation and scour protection.

— Seaway Heavy Lifting (SHL) - is a privately owned operator of high lift capacity floating crane barges. SHL services are mainly focused on the oil and gas sector. They have two extremely high capacity Heavy Lift Vessels. For offshore wind the SHL niche offering is in the installation of the heavy offshore substations and associated jacket foundations. SHL are also building a track record of monopile foundation installation with over 200 installed at Greater Gabbard and Sheringham Shoal. SHL have a further commission for Riffgat.

— DEME – is a major integrated dredging, land reclamation and offshore contracting group, owned by Ackermann and Van Haaren, an investment group, and CFE, a subsidiary of French Contractor, Vinci. Specialist vessel operators Geosea and Scaldis Salvage & Marine are part of the DEME group.

— Geosea owns and operates a number of smaller jack-up barges that have been used for pre piling work on jacket foundations, installation of transition pieces and installation of turbines. GeoSea is also building a new self-propelled jack-up vessel. GeoSea is also a 50% JV partner with Hochtief in HGO Infrasea, which is building a new jack up installation vessel.

— Scaldis Salvage and Marine has a niche heavy lift capability and their vessel has been used for installation of substation topsides, for turbine installation on the Beatrice experimental project, and for jacket foundation installation at Ormonde.

— Ballast Nedam operate principally as an installation contractor but have a single jack-up barge that is suitable for use in shallow waters.

[32] EWEA, Opening Up Offshore, Wind Directions, September 2009

[33] FT, March 19, 2012

New entrants that are expected in the European market in 2012/13 include: Swire, Fred Olsen, RWE, Workfox and Van Oord. A total of 10 vessels are entering service during 2012/13.

Whilst the turbine installation market is currently well resourced, bottlenecks are likely to occur in the cable installation market. [34] With a significant increase in the volume of export cable needing to be installed between 2011 and 2019, along with rising demand for inter-array cabling installation. Currently, this market is characterised by players with weak financial strength and poor track record with only a few main actors such as:

— Global Marine Systems

— Volker Stevin Marine Contractors (Stemat is a sister company)

— JD Contractors

— Van Oord

— Technip (who recently purchased SubOcean – formally CNS)

— Subsea7.

— Reef Subsea and Technocean AS

Offshore Marine Management and CT Offshore are now trying to break into the market and probably will do. CT Offshore will now become the cable installation company for DONG as they are 67% owned by A2SEA.

[34] GL Garrad Hassan, Wind in our sails, EWEA, 2011.

2.6 Summary of current capacity assessment

Current capacity assessment

This section of the report sets out a summary of current capacity in the European offshore wind supply chain and the additional resource that we anticipate will be available by 2013/14, based on public announced investments. The assessment excludes new UK turbine manufacturing capacity, which is not expected to come on stream until 2015. The analysis set out in Table 13 below is used as the starting point of the assessment of the supply/demand balance detailed in tables 14 to 16 in section 2.7 below. Capacity of vessels describes the capacity for separate installation operations – foundations and turbine installations are counted as two operations.

Table 13: Summary of current capacity and short term capacity enhancement.

Industry Segment	Number of current participants	Approximate annual capacity (2012)	Number of new entrants	Approximate additional annual capacity	Total annual capacity (2013/14)
	(nr)	(nr)	(nr)	(nr)	(nr)
Turbines <5MW	2	300-400	n/a		300-400
Turbines >5MW	3	100 - 200			100-200
Monopile foundations	8	1,000	n/a		1,000+
Tripod/jacket foundations	4	100 - 200+	1 (from 2012)	50+	200+
Gravity foundations	1	100	4 (timescale unknown)	200 +?	300+
Installation contractors	3/4	300 – 400			300 - 400
Installation vessels - <5MW	8	640	n/a		640
Installation vessels - >5MW	4	320	10 (2012 to 2013)	800	1120

Source: EC Harris

Peak turbine installation rates in the most recent development phase occurred in 2010 and 2011, at around 300 per annum. The analysis above, based on the detailed assessment of baseline capacity shows that once recent market entrants are taken into account, there is ample capacity to deliver at the build rate anticipated for 2012 to 2015, in terms of turbine output, foundations and vessels.

The analysis also shows that there is limited, but sufficient capacity in the large turbine/deep water supply chain to enable a steady ramp up of growth in the >5MW market. As previously discussed, the principal constraint appears to be in the installation management supply chain – with only four or five current players. Our view is that relatively low barriers to entry mean that, compared to other elements of the supply chain, this constraint is likely to be removed – assuming that conditions are in place to encourage the diversification by major European contractors into this market.

Conclusions

The pipeline of new turbine development is encouraging and – assuming that certainty of volume can be demonstrated through consents and orders – investment in capacity is likely to occur. However, without a secure order book, investment will not proceed within the timescales necessary to support decisions for the rapid expansion of delivery capability prior to FID 2014. In our assessment of capacity constraint in table 16 below, we have assumed that manufacturers will confirm these investment decisions – increasing capacity ahead of production for FID 2014 to 600 to 900 turbines per annum

Assuming workload is secured, Siemens and Vestas are likely to have UK-based capacity by 2015. Other competing manufacturers including Areva and RePower also have existing 5MW capacity in Europe. There is unlikely to be a capacity constraint in 2015, but significant investment will be required by a range of players including non-European participants to maintain volumes towards FID2020.

The shift to jacket and tripod foundations associated with larger turbines and deeper waters has the potential to create capacity constraint. Current capacity for the wind industry is approximately 200 jackets per annum. Existing monopile fabricators could diversify, following the example of TAG, although they are typically medium-sized businesses with a specialist skills base in heavy sheet steel fabrication. Early large contractor interest in gravity foundations has long-term potential for investment and significant additional capacity. Current capacity in jacket fabrication focused on the Oil and Gas business could switch to jackets and tripods to increase capacity- e.g. OGN of Wallsend.

Current procurement strategies for foundation installation favour a mini-EPC model with an installation specialist taking responsibility for design fabrication and installation of monopiles, transition pieces and aspects of balance of plant. There is a limited pool of contractor expertise in this area. These contractors are of medium scale – (€1 to 2bn pa turnover), privately owned, and operate globally. They include Van Oord, MT Hogjaard, ABJV and Ballast Nedam. There are 4 or 5 active in the market at present. This represents a capacity constraint, but barriers to entry are low. Due to the scale of financial exposure on off-shore wind projects, EPC and mini-EPC contractors are likely to be cautious in managing their exposure to projects. As a result growth of capacity is likely to be incremental. This is a potential area of risk but with a highly diversified European civil engineering contractor market there is a significant pool of available resource to build from. Lack of installation contractor capacity will reduce the range of procurement options available to developers – potentially requiring a greater reliance on a multi-contract strategy

Delivery of 10 large multi-purpose vessels in 2011 and 2012 suggests that there is unlikely to be a capacity constraint affecting foundation or turbine installation during the initial ramp up of activity post FID 2014. With existing spare shallow water capacity there should be sufficient vessels to meet demand. Demand from alternative uses in European Waters such as Oil and Gas decommissioning could create capacity constraint for specialist vessels such as heavy lift barges required for larger structures. Similarly rapid evolution of larger turbines of 8MW + may trigger the development of a further generation of installation vessels. FID will be required in 2015/16 to meet likely deliver dates.

2.7 Supply/demand balance

In this section of the report, we compare current and announced capacity with projected demand based on the four demand stories developed for the study. The objective of the analysis is to assess the growth in supply chain capacity necessary to meet projections for additional European demand in line with the four stories.

Capacity Assessment

Table 14 and Table 15 set out an analysis of the capacity implications of the demand stories described in sections 1 and 3. The analysis has been prepared as follows:

- Table 14 details UK capacity, whereas Table 15 details capacity for all of Europe, including the UK.
- The assessment focuses on the key areas of capital expenditure – turbines, foundations, installations and installation vessels. Array cable and substation capacity is excluded from the assessment;
- We have used an assessment of additional UK capacity prepared by TCE as the basis of the demand calculation. Projections of additional capacity on are taken from the market shares model described in the technology work stream report by BVG.
- The analysis converts annual additional capacity in UK water into numbers of turbines, foundations, array connections and installation operations.
- Demand stories used are based on the site C variant of the model.
- Turbine manufacture and foundation installation are assumed to commence one year after FID. Turbine installation is assumed to commence two years after FID.
- Our assessment of demand from the rest of Europe is notional. We have calculated European demand using ratios derived from the UK's share of the Europe Wind market described in the stories. The calculation of European demand in derived directly from the TCE's assessment of growth in UK waters.

— The mix of turbine sizes varies in accordance with each story and evolves over FID 2014, 2017 and 2020. This affects the number and type of foundations and installation operations required to deliver each additional MW of capacity.

— For each turbine, there are two installation operations – support structure and turbine. The installation of the foundation occurs in the year before the turbine is installed. Work associated with balance of plant is excluded.

— An assessment of the cumulative growth in O&M contracts is also included in the table. No adjustment to the number of O&M contracts is made to account for fixed warranty periods. The assessment shows that whilst there is not an established O&M industry associated with Offshore Wind, by the end of FID 201, there will be between 4,000 and 6,000 turbines requiring maintenance support as they come out of their warranty periods – a significant long-term driver with which to establish a dedicated supply chain. No further analysis of the O&M supply chain is made, as it is not yet in place.

The projection is extended to 2030, but no further investment decisions are modelled post 2020. In Table 16 this period is termed *FID23*. The assessment of a post-2020 scenario is useful as it provides an indication of the size of the likely medium term pipeline, against which supply chain investment decisions will be made. Additional offshore capacity over and above that described in

Table 14 may be added post 2020, as the UK continues its low-carbon transition, but this is excluded from the assessment.

The demand profile for each supply chain sector is plotted in Figure 12 summarising the annual outputs for each story, showing the timing of peak levels of activity and the relative size and sustainability of post peak workload.

In order to identify where constraints could emerge, we have compared the results of this assessment to the calculation of current and short term European market capacity detailed in Table 15 This comparison is presented in Table 16 below, highlighting where supply and demand are in balance, or where there are conditions of potential under or over-supply could potentially emerge.

Table 14: UK-only capacity implications of demand stories

Slow Progression	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Additional Capacity(MW)		770	273	530	144	285	368	384	1,402	2,725	3,300	1,800	1,700	1,600	1,500	1,400	1,300	1,200	1,100	1,000	900	23,681
Turbine(nr)		193	68	133	33	65	84	80	292	568	583	318	300	283	265	247	230	212	194	177	159	4,484
Foundation(nr)	96	130	100	83	49	75	82	186	430	575	451	309	292	274	256	239	221	203	186	168	79	4,484
Installation(nr)	96	323	169	215	82	140	167	266	722	1,143	1,034	627	592	557	521	486	451	415	380	345	239	8,967
O&M (total nr)	500	500	693	761	893	926	992	1,076	1,156	1,448	2,016	2,599	2,917	3,217	3,500	3,765	4,012	4,242	4,454	4,648	4,825	
Technology Acceleration																						
Additional Capacity (MW)		770	273	530	429	1,526	1,500	2,100	2,400	2,575	3,165	2,800	2,600	2,400	2,300	2,300	2,200	2,200	2,200	2,200	2,200	38,668
Turbine(nr)		193	68	133	89	318	313	349	399	428	419	371	345	318	305	305	292	292	292	291	292	5,809
Foundation(nr)	96	130	100	111	204	315	331	374	414	424	395	358	331	311	305	298	292	292	292	292	146	5,809
Installation(nr)	96	323	169	243	293	633	643	723	813	852	815	729	676	629	610	603	583	583	583	583	437	11,618
O&M (total nr)	500	500	693	761	893	983	1,301	1,613	1,962	2,361	2,789	3,209	3,580	3,924	4,242	4,547	4,852	5,143	5,435	5,726	6,018	
Supply Chain Efficiency																						
Additional Capacity (MW)		770	273	530	429	1,526	1,500	2,100	2,400	2,575	3,165	2,800	2,600	2,400	2,300	2,300	2,200	2,200	2,200	2,200	2,200	38,668
Turbine(nr)		193	68	133	98	350	344	394	450	483	514	455	423	390	374	374	358	358	358	357	358	6,828
Foundation(nr)	96	130	100	115	224	347	369	422	466	499	485	439	406	382	374	366	358	358	358	358	179	6,828
Installation operations(nr)	96	323	169	248	322	696	713	816	916	981	999	894	829	772	748	739	715	715	715	715	536	13,657
O&M (total nr)	500	500	693	761	893	992	1,341	1,685	2,079	2,529	3,012	3,526	3,981	4,403	4,793	5,167	5,541	5,898	6,256	6,613	6,971	
Rapid Progression																						
Additional Capacity (MW)		770	525	533	905	2,100	2,600	3,600	3,600	3,600	3,600	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,600	2,600	48,633
Turbine(nr)		193	131	133	189	438	542	599	599	599	477	358	358	358	358	358	358	358	358	345	344	7,448
Foundation(nr)	96	162	132	161	313	490	570	599	599	538	417	358	358	358	358	358	358	358	351	345	172	7,448
Installation (nr)	96	354	264	294	502	927	1,112	1,197	1,197	1,136	894	716	716	716	715	716	716	715	709	689	517	14,896
O&M (total nr)	500	500	693	824	957	1,146	1,583	2,125	2,723	3,322	3,920	4,397	4,755	5,113	5,470	5,828	6,186	6,544	6,901	7,259	7,604	

Table 15. European-wide capacity implications of demand stories

Slow progression	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Additional Capacity(MW)		1,989	705	1,369	372	736	951	992	3,622	7,040	8,525	4,650	4,392	4,133	3,875	3,617	3,358	3,100	2,842	2,583	2,325	61,176
Turbine (nr)		497	176	342	85	169	218	207	755	1467	1506	822	776	730	685	639	593	548	502	456	411	11583
Foundation (nr)	249	337	259	214	127	193	212	481	1111	1486	1164	799	753	707	662	616	570	525	479	434	205	11583
Installation (nr)	249	834	436	556	212	362	430	687	1865	2953	2670	1620	1529	1438	1346	1255	1164	1073	981	890	616	23166
O&M (total nr)	1292	1292	1789	1965	2308	2393	2562	2779	2986	3741	5207	6713	7535	8311	9041	9725	10364	10958	11505	12007	12464	
Technology Acceleration																						
Additional Capacity(MW)		1,631	578	1,122	908	3,232	3,176	4,447	5,082	5,453	6,702	5,929	5,506	5,082	4,871	4,871	4,659	4,659	4,659	4,659	4,659	81,885
Turbine (nr)		408	145	281	189	673	662	739	845	907	888	786	730	673	645	645	617	617	617	617	617	12302
Foundation (nr)	204	276	213	235	431	668	701	792	876	897	837	758	701	659	645	631	617	617	617	617	309	12302
Installation (nr)	204	684	357	516	621	1341	1362	1531	1721	1804	1725	1543	1431	1333	1291	1277	1235	1235	1235	1235	926	24603
O&M (total nr)	1059	1059	1466	1611	1892	2081	2754	3416	4155	5000	5907	6795	7580	8310	8983	9629	10274	10891	11509	12126	12743	
Supply chain efficiency																						
Additional Capacity (MW)		1,631	578	1,122	908	3,232	3,176	4,447	5,082	5,453	6,702	5,929	5,506	5,082	4,871	4,871	4,659	4,659	4,659	4,659	4,659	81,885
Turbine(nr)		408	145	281	208	741	728	834	953	1022	1089	964	895	826	791	791	757	757	757	757	757	14460
Foundation(nr)	204	276	213	244	474	734	781	893	988	1056	1026	929	860	809	791	774	757	757	757	757	379	14460
Installation operations(nr)	204	684	357	525	683	1475	1509	1727	1941	2078	2115	1893	1755	1635	1583	1566	1514	1514	1514	1514	1136	28920
O&M (total nr)	1059	1059	1466	1611	1892	2100	2840	3568	4402	5355	6377	7467	8430	9325	10151	10942	11734	12491	13248	14005	14762	
Rapid Progression																						
Additional Capacity (MW)		1,406	959	973	1,653	3,835	4,748	6,574	6,574	6,574	6,574	4,930	4,930	4,930	4,930	4,930	4,930	4,930	4,930	4,748	4,748	88,808
Turbine (nr)		352	240	243	344	799	989	1093	1093	1093	871	653	653	653	653	653	653	653	653	629	629	13601
Foundation (nr)	176	296	242	294	572	894	1041	1093	1093	982	762	653	653	653	653	653	653	653	641	629	315	13601
Installation (nr)	176	647	481	537	916	1693	2030	2186	2186	2075	1633	1307	1307	1307	1307	1307	1307	1307	1294	1258	944	27202
O&M (total nr)	913	913	1265	1504	1748	2092	2891	3880	4973	6066	7159	8030	8683	9336	9990	10643	11296	11949	12603	13256	13885	

Source: EC Harris

Figure 12: Annual Outputs Summary (based on Table 14, UK only),

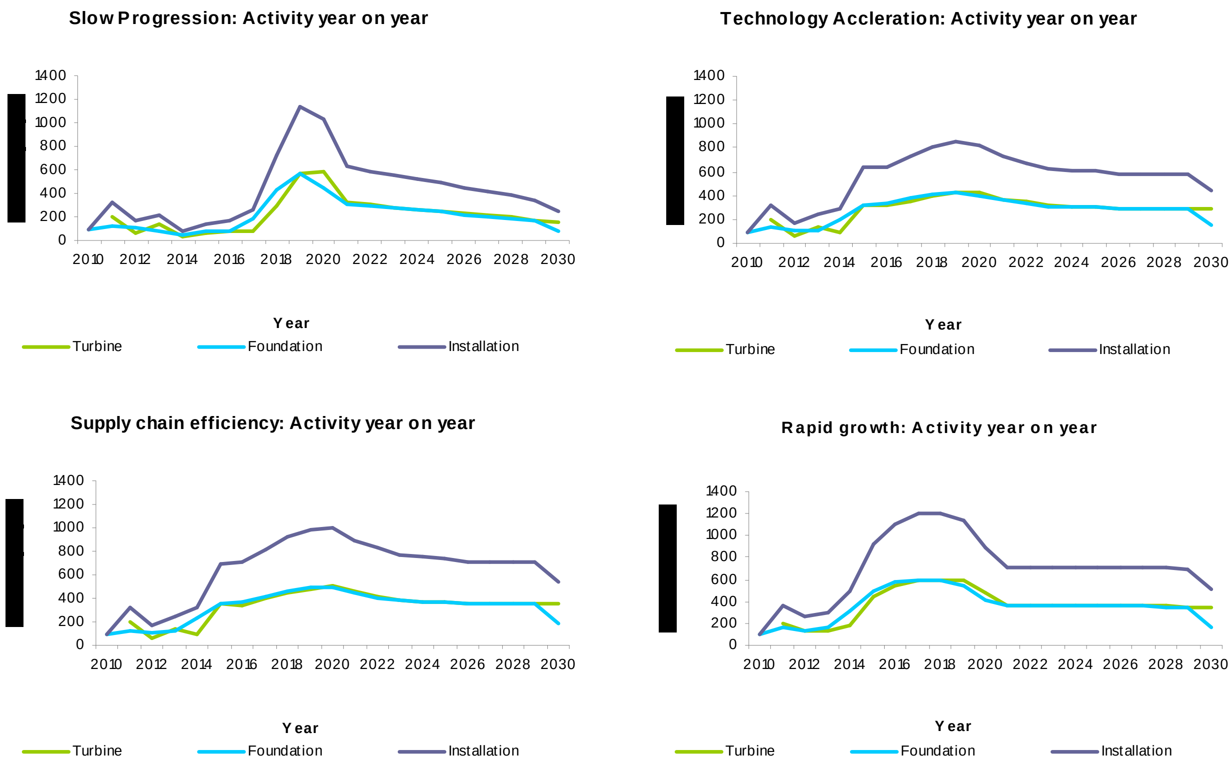

Figure 12 shows that capacity stories have the following characteristics:

— The slow progression story is characterised by a very rapid increase in demand after FID17, peaking in 2019 and 2020, which is not sustained into later phases of development. Despite the relatively low overall capacity delivered by the Slow Progression story, capacity constraint could potentially affect turbine OEMs, installation contractors and vessel operators post FID-2017. Even in the slow progression story, there is potentially an installation contractor capacity constraint after FID14, which due to the rapid ramp up in demand post FID 2017 could continue until 2020.

— Under the technology acceleration story, demand growth is steady and turbine capacity remains broadly in balance during FID14 and FID17. Peak activity is lower than in the slow progression story. It should be noted that this outcome is dependent on investment in 5MW+ turbine technologies over this period. The main pinch points could be installation contractor availability, due to the high rate of output from 2014 onwards, and availability of high capacity vessels post FID 2017, due to the high investment and long lead-in for vessel development.

— The supply chain efficiency story involves a slightly faster rate of growth in demand for installation capacity and turbine manufacture in FID14 in particular due to a greater reliance on smaller turbines based on established technologies. This scenario requires more installation capacity, but is not materially different from the technology acceleration story in terms of wider capacity requirements. Post FID2020 levels of output under the supply chain efficiency scenario are higher than either the technology acceleration of rapid progression stories – providing the optimum basis for the operation of the cost reduction levers of competition and certainty in asset growth.

— The rapid progression story involves a rapid increase in activity from 2014 onwards, requiring early investment, a peak of activity after FID 2017 and a large difference between peak output and post-FID2020 activity – when measured in terms of physical output rather than installed capacity. The rapid progression story benefits from economies of scale achieved through use of larger turbines previously discussed in section 2.3. However, the need to introduce new turbine technologies, foundations and vessels to meet the rapid progression story may accelerate the obsolescence of current technologies, either reducing the attraction for investors, or requiring a faster rate of return on investment, increasing costs.

The rapid progression story illustrates the impact of technological change between FID 2014 and FID 2020, which could in turn create capacity constraint. A good example is the shift from monopile foundations to jackets associated with the use of larger turbines in deeper waters. It should be noted that, other than changes in turbine capacity, which determines the number of foundations and installations required to deliver a certain capacity, no other aspects of technology change has been modelled in the assessment presented in tables 14 and 15 and Figure 12.

Capacity Analysis - Conclusions

Table 16 summarises projections of current and short term supply chain capacity our demand projections for each story. Capacity is measured by physical output – number of turbines, number of installation operations and so on, rather than generating capacity. The minimum and maximum levels of demand for the years following FID 2014, FID 2017 and FID 2020 are summarised and compared to available capacity in the supply chain in the period preceding the FID. Colour coding is used to illustrate whether there is potential surplus capacity or a constraint, or whether supply and demand are reasonably in balance. Constraints in turbine manufacture or installation capacity are likely to be addressed through the involvement of new entrants into the market.

Table 16: Capacity demand summary

	Current EU capacity (nr)	Anticipated EU capacity (2013/14) (nr)	FID 2014 (European demand) (nr)	FID 2017 (European demand) (nr)	FID 2020 (European demand) (nr)	FID 2023+ (European demand) (nr)
Slow Progression						
Turbines	400 – 600	600 - 900	170 - 210	750-1,500	730-820	410 - 690
Foundations	1200 +	1,450+	150 - 480	1,100 – 1,480	700 - 800	210-670
Installations	300 – 400	300 +	360 - 690	1,860 – 2,950	1,440 – 1,620	620 – 1,350
Vessels (foundation and turbine only)	900+	1,700+	360 - 690	1,860 – 2,950	1,440 – 1,620	620 – 1,350
Technology Acceleration						
Turbines	400 – 600	600 - 900	660 - 740	850 - 910	680 - 780	610 - 640
Foundations	1200 +	1,450+	680 - 780	850 - 890	660 - 760	610 - 640
Installations	300 – 400	300 +	1,330 – 1,520	1,720 – 1,800	1,330 – 1,550	930 – 1,290
Vessels (foundation and turbine only)	900+	1,700+	1,330 – 1,520	1,720 – 1,800	1,330 – 1,550	930 – 1,290
Supply Chain Efficiency						
Turbines	400 – 600	600 - 900	720 - 830	950 – 1,080	830 - 970	760 - 780
Foundations	1200 +	1,450+	740 - 890	1,000 – 1,060	800 - 930	380 - 780
Installations	300 – 400	300 +	1,480 – 1,740	1,950 – 2,120	1,630 – 1,880	1,140 – 1,590
Vessels (foundation and turbine only)	900+	1,700+	1,480 – 1,740	1,950 – 2,120	1,630 – 1,880	1,140 – 1,590
Rapid progression						
Turbines	400 – 600	600 - 900	800 – 1,100	880 – 1,100	660 - 660	620 - 660
Foundations	1200 +	1,450+	890 – 1,100	770 – 1,100	660 - 660	310 - 660
Installations	300 – 400	300 +	1,700 – 2,190	1,630 – 2,190	1,310 – 1,310	950 – 1,310
Vessels (foundation and turbine only)	900+	1,700+	1,700 – 2,190	1,630 – 2,190	1,310 – 1,310	950 – 1,310

Source EC Harris

Key

= Constrained capacity *= Balanced supply and demand capacity* *= Surplus capacity*

Notes:

Current capacity is our assessment of capacity that is immediately available for utilisation in 2012.

Anticipated capacity includes our assessment of the impact of new committed investment into the supply chain that will come on-line in 2012-2014. Our assessment of UK-based turbine manufacturing capacity reflects new capacity that is currently at various stages of investment, that will be confirmed to developers prior to FID 2014.

Demand is for all of Europe in line with the four stories, and is expressed in number of components or operations.

The range for each FID describes the demand profile that follows FID in 2014, 2017 and 2020 and is determined by analysis provided by TCE

Demand in periods FID 2017 onwards is compared to the volumes of workload in the preceding period to determine the supply/demand balance. It is assumed that the capacity will have been put place to meet the previous volume e.g. if demand in FID2017 is substantially higher than FID 2014 and the existing capacity, then a constraint will emerge.

The main conclusions that can be drawn from the analysis in Table 16 are as follows:

— Demand in the FID 2014 period for most stories is similar to that experienced in Europe during 2011 to 2012 and as a result, capacity will be sufficient or in surplus for most stories (see rapid progression below).

— Capacity constraint affects installation contractor availability in all stories from FID 14 onwards. Early attraction of additional capacity in all stories other than slow progression shows how important the early assurance of volume will be to the establishment of cost reduction levers in the supply chain. In the case of slow progression, installer constraint could continue through to the end of FID 2017

— Turbine manufacturing capacity constraint will affect the rapid progression story from FID2014. With new manufacturing capacity expected to come on stream in 2015 in the UK, our view is that capacity for the technology acceleration and supply chain efficiency stories will be in balance during FID 2014, but will require sustained investment to address continuing growth in volumes post – FID2017. In slow progression, turbine demand peaks in FID2017 and falls away very quickly – providing a limited opportunity for investors to secure a return on investment in additional capacity.

— Depending on the technology adopted, foundation capacity could be significantly under-utilised based on Europe-wide demand for much of the development period. Our view that is that jacket and gravity foundation specialists have global markets in oil and gas, which will help to keep supply and demand in balance. Monopile specialists, currently have substantial capacity in the European market which initially will be underutilised. Looking forward, their market share will be threatened by jacket and tripod manufacturers, and they may either opt to develop new capacity, or may exit the market so that capacity is better aligned with demand.

— Vessel capacity is assessed to be in surplus or in balance for all scenarios other than rapid progression post FID2014. There is potential for constraint related to volume in FID2017 in most stories. Looking beyond FID 2017, the implications of technological obsolescence driven by the introduction of larger turbines could have a significant impact on the willingness of vessel owners to invest in new equipment. This affects scenarios shown to be in surplus from a aggregate capacity perspective, including technology acceleration and rapid progression.

The main implications for the stories are:

— The slow progression scenario delivers significantly less generating capacity but still results in a short but significant peak of activity around FID 2017. Competitive conditions are likely to be favourable for technology, but the pattern of work – particularly the large volume of installation work – is less likely to support investment in building capacity. This could reduce the effect of some cost reduction levers such as certainty of future demand and economies of scale.

— The demand implications of technology acceleration scenario are difficult to project as the story relies on assumptions with regards to the presence of new market entrants in turbine technology and continuing investment in fabrication and vessel technologies. Use of larger capacity turbines is likely to reduce pressure on available installation capacity other than for specialist large capacity vessels. Installation capacity is a large potential constraint, but is the market with the lowest barriers to entry. Competitive conditions are likely to be in place for currently modelled demand from FID 2020 onwards.

— The supply chain efficiency scenario provides an extended window of peak activity (FID2017 onwards) which will support investment decisions. Overall, utilisation of resources is effective. However, the high volume of installation activity from 2017 onwards could potentially result in capacity constraint focused on the installation supply chain. Competitive conditions are likely to be in place for currently modelled demand from FID 2020 onwards.

— The rapid progression story involves significant imbalance between demand and supply from FID2014 onwards, which will then result in sufficient capacity to deliver peak output after FID2017. There is a risk of over capacity across all supply chains post FID2020, even though the story delivers more installed capacity. The Rapid Progression scenario involves rapid rates of technological change which could in turn result in accelerated obsolescence in the supply chain. This risk, combined with the requirement for rapid investment ahead of FID2014 suggests that the rapid progression story is difficult to justify from a viability perspective.

The conclusion of this assessment is that based on current European capacity and the time available to attract and built additional capacity, the offshore wind industry will have access to resource to deliver the UK programme, which in turn will encourage elements of competition alongside investment in models of collaboration and cooperation.

Reliance on new technologies and investment will mean that in initial phases new entrants will need to prioritise return on investment. As a result market mechanisms to assure volume such as alliances, frameworks and long-term contracts may be widely adopted during FID14 and FID17. Scenarios with extended and stable post peak tails – supply chain efficiency and rapid progression – may create the optimum conditions for investment certainty, resulting in balanced capacity and effective operation of markets.

Given current levels of activity, the slow progression scenario could take place. It is potentially resource inefficient involving a short peak of activity focused on existing technologies followed by a shift to small volumes of larger 6MW turbines – the scenario will deliver less capacity and may not result in a sustainable flow of work to support investment in UK industry..

In all scenarios, the availability of installation capacity is flagged up as a source of potential limitation. The capacity required is a combination of project and programme management, site supervision, logistics, working capital and risk management. The limited number of players currently operating in the market needs to be expanded. Fortunately, the timescales required to build management capacity are faster than those associated with building fixed facilities such as factories or vessels. However, considering the risk exposure on some contract variants such as a large-scale bundled EPC, other potential market entrants may conclude that the wind sector may not offer the appropriate risk: reward balance that contractors require. In both technology acceleration and rapid progression, the need to rapidly increase volumes in jacket fabrication might also result in some constraint – although there are many UK and European fabricators currently entering this segment.

2.8 Summary

In this section we have reviewed the dynamics of the Global, European and UK wind markets, and have reviewed the existing project portfolio. We have provided an overview of developers and key elements of the supply chain – particularly OEMs, foundation manufacturers, installation contractors and vessel operators. We have provided an assessment of current and likely short term capacity and have used this as a base line to determine the likely supply/demand balance as capacity builds up over the next decade.

We have aligned our capacity assessment with the stories developed in the technology work stream report so that the discussion on the potential contribution of the cost reduction levers can be placed into context of current and future capacity.

The following key issues summarise the findings of this section:

— Growth in demand for wind energy slowed down in 2010 as a result of economic slowdown in Europe and the US. This has affected short term investment planning and has heightened the importance of certainty of future workload. However demand for wind energy is forecast to grow rapidly and expectation for high levels of growth and investment underpins assumptions with regards to the potential for large numbers of new entrants.

— The offshore wind segment is relatively small, accounting for 1.5% of total installed capacity. The UK currently has a leadership position as a result of an accelerating rate of installation since 2005. The UK is currently the focus for the largest developments using established technologies. However, European-commissioned schemes located in the Northern North Sea are adopting new turbine technologies at scale ahead of UK developers.

— The UK has a relatively constrained pipeline of consented schemes. The implication is that there will be a hiatus of workload ahead of a rapid acceleration post FID 2014. Our assessment of current capacity is that there is ample capacity to deliver at the build rate anticipated for 2012-2015.

— Elements of the UK offshore wind supply chain are diverse – particularly with regards to foundation fabricators and vessel suppliers. Turbine supply is limited to two major players, but there is ample evidence of commitment to invest in the UK from other OEMs. The supply chain segment with the lowest diversity, which also potentially has capacity constraints, is the installation supply chain. This could become more significant if developer JVs seek to use a bundled approach to procurement to manage their risk exposure.

— We have assessed the demand/supply balance for the turbine, foundation, installation and vessels segments and have shown that all stories will experience a capacity constraint at some point in their evolution – the key issues are the timing of the constraint, and whether capacity put in place to meet peak demand will be properly utilised post 2020. The Technology Acceleration and Supply Chain Efficiency stories present the best combinations of managed ramp-up of capacity for FID 2014 and peak capacity post FID 2017

— Securing investor certainty will be critical in building the supply chain to deliver the off-shore wind programme cost effectively. Workload profiles with a relatively low peak and long stable tail are best configured to deliver this investor certainty. The supply chain efficiency story matches this requirement and is used as the basis of the assessment of supply chain levers in section 4

3 Cost Reduction Levers

3.1 Introduction

The cost reduction drivers and opportunities for cost savings in the offshore wind industry are often interlinked across technology, finance and supply chain. In this project it has been necessary to identify and prioritise the factors of most relevance to each work stream capturing the associated impacts separately and then reflecting the interrelationships in the resulting pathways.

For the supply chain work stream, levers that reflect the role and ability of the supply chain to affect savings, in isolation from technology change and financial issues have been identified. These are largely independent from each other in order to assess their impact in a discrete way.

The levers that have been identified include:

- Increased competition from European players.
- Increased competition from low cost jurisdictions.
- Vertical collaboration (which includes Interface risk).
- Asset growth and economies of scale.
- Horizontal cooperation.
- Changes in contract forms/terms.
- Means of managing uncontrollable risk.

Each of these supply chain levers is defined below setting out their remit and the current baseline against which cost reductions have been assessed to the period 2020.

3.2 Competition

As indicated in Section 2, in certain areas of the offshore wind supply chain such as wind turbine manufacture and the provision of installation and O&M services (including suitable vessels) there are currently few competitors. These conditions led to bottlenecks in supply and high prices in recent peak years of production. As demand increases post-2015, these conditions could be repeated unless additional investment is made by the supply chain.

The creation of competitive conditions is dependent initially on the attraction of additional investment into the European offshore wind sector.

Investment in capacity has been made by vessel operators and by support structure fabricators. Turbine manufacturers have so far invested in product development but have not put manufacturing capacity in place. UK-based investment in turbine production capacity will only occur if the deployment rate rises to around 2GW per annum, for UK projects this means a market size of 17GW (operational by 2020).

In balanced markets, it is reasonable to assume that players will price their products to recover costs (labour, materials and sunk investment in plant and R&D) and earn “normal” profit. Based on segment results from Siemens, Vestas and General Electric, net profit in energy industries has been in the range of 10-20% over the past five years. In constrained or undersupplied markets, high demand will result in higher prices as a result of a combination of increased input costs and increasing margins. This was the case in the CCGT and supercritical coal market where prices increased by the same order of magnitude as underlying costs during a period of supply shortages.[35]

[35] Costs of low-carbon generation technologies, May 2011, Committee on Climate Change, Mott MacDonald

The opposite effect occurs when there is over supply. There is plenty of evidence of falling prices in the wind turbine supply market since 2009, including data from Berkeley Lab[36] and published reports in Asian Power[37] which describe the margins of two leading Chinese turbine manufacturers, Huarui and Golden Wind, falling by 49% and 60% in the first 3 quarters of 2011.

Other factors which continue to affect competition in the European Offshore wind market include high barriers to entry related to technology, proof of concept and investment in plant and the effects of availability and price reliance in parts of the second tier supply chain. Relevant examples of this for offshore wind include the constrained supply chain for gearboxes and price fluctuations affecting the rare earth metals that are a key raw material for the magnets used in direct-drive turbines.

Looking forward, as the range of market entrants in offshore wind grows from two to six or more turbine manufacturers, competing suppliers will adopt differentiation strategies to mitigate the effects of price competition. In wind, this is likely to focus on minimising levelised cost of energy (LCOE). Examples of strategies to deliver optimum LCOE include:

- Product innovation associated with turbine size – 8 turbine manufacturers have announced plans to develop turbines with a capacity in excess of 10MW.[38]
- Product innovation associated with reliability – Mitsubishi are developing a gearless hydraulic drive, whilst other manufacturers including Siemens, Alstom, GE etc., have been developing gearless systems based on permanent magnet generators.
- Service innovation based on optimisation of output and availability – suppliers such as Vestas have developed a proprietary Active Output Management offering (AOM) including energy-based availability guarantees.

Competition on an LCOE basis is likely to make the purchasing decision more complex in the medium term.

Competition from European Entrants

The cost base of offshore wind parks currently being completed in the UK was determined by procurement undertaken in 2007/2008 during periods of peak demand. The 2008/2009 financial crisis and its aftermath have had a significant effect on the wind market – affecting demand for energy. In the short term, production volumes have fallen, providing direct evidence of the potential impact of competition within the European market.

Recent results from Vestas and Siemens show that competitive forces have affected margins since the 2008/2009 financial crisis. Whilst offshore installation volumes in Europe have remained stable during 2009 and 2010 with some increases in Germany, volumes in other available markets – particularly Spain and the US have declined significantly. According to Bloomberg New Energy Finance,[39] global volumes of wind turbine purchases fell 14% year on year on 2011. The WilderHill New Energy Global Innovation Index, which currently has a 16% weighting in wind energy is currently 33% of its peak value recorded in Q42011.

Other participants will need to enter the market and increase capacity if the market conditions seen in 2007/8 are not to be repeated. The effect of increased competition from European players with similar cost profiles as current incumbents is likely to be the lowering of the potential for ‘supra-normal’ profits seen in 2008 and 2009 in response to high demand.

Other potential savings will come through reductions in the cost base by for example rationalising procurement and putting pressure on sub-component suppliers. In this case, sub-components may be sourced from low cost countries but the end product branded as a product of western OEM or balance of plant supplier. This can be evidenced from current sourcing strategies of Siemens, Vestas and others for onshore wind. Towers, bearings and other components are already sourced from low-cost countries, and Siemens has announced a strategic objective to increase the industrialisation of manufacturing and

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[36] US Department of Energy, 2010 Wind Technologies market Report, June 2011

[37] Asian Power, “focus moves to china’s offshore wind as onshore profit margins shrink”, Dec 2011

[38] GL Garrad Hassan, Wind in our sails, EWEA, 2011

[39] Bloomberg, First Solar to Vestas Wind Profit crash deters new CEOs, 13 February 2012

logistics – nacelles for continuous flow manufacturing process, and rotor blade production will shortly be automated. REpower claims that extended use of emerging market supply chains has reduced their costs by 15%.[40]

The extent of the cost reduction will depend on a number of issues:

- The size of the market and its ability to attract new players.
- Number of players able to overcome barriers of entry. Barriers to entry include:
    - Bankability', which relies on the ability to demonstrate long-term performance. Woodlawn Associates[41] describe a hierarchy of bankable manufacturers, with Repower, Nordex and Mitsubishi being described as 'respected second tier' compared to market leaders, GE, Siemens and Vestas. New entrants need to test prototypes and demonstrate two years' operating track record in similar operating conditions (North Sea), prior to the product becoming attractive to purchase.
    - Technical compliance. Different technical standards may require re-engineering. These barriers typically affect competition from low-cost jurisdictions.
- The ability of new suppliers to produce the necessary volumes to the required quality – this becomes a more significant barrier as turbines and components increase in size and order become larger in volume.
- New entrant pricing strategy as they will need to recover the cost of entry (e.g. product development).

This lever explores how competition from European players may evolve under the market volume trajectories stipulated in each of the study stories against the present situation as set in the table below.

Table 17 Current Status 2011 for European Competition

2011 Baseline for European Competition.	
Turbines	Slow, low volume market with a weak pipeline of work. One dominant European player, one significant competitor, 2/3 potential entrants with differentiated technologies. New entrants reliant on increased volumes to support investment
Support structures	Sufficient capacity in monopiles (8 suppliers). Limited and unproven supply in jackets and tripods – 3 or 4 participants
Array cables	Competitive market for inter-array cabling at medium voltage.
Installation	Undersupplied market with 3-4 contractors capable of delivering mini-EPC solutions. Sufficient supply of vessels for turbines and foundations as a result of new capacity entering market – including 10 with >5MW capacity by 2012/13. Constraint in quality and financial strength of cable installers with specialised vessels. Competitive pressures are low.
Planned O&M	Provided by OEMs. No stand-alone suppliers or dedicated vessels.
Unplanned O&M	Linked to OEMs. No stand-alone suppliers or dedicated vessels.

Competition from Low Cost Entrants

Potential step changes in costs may arise from competition from low cost countries (India and the Far East, including for example, China, South Korea and Japan).

Seven Chinese turbine manufacturers are in the global top 15 wind turbine manufacturers by value of orders. Most turbines are targeted at the domestic market. Chinese wind technologies are reputed to perform less well than European equivalents, as well as having lower reliability - thus resulting in higher LCOE. Whilst this balance between capex and opex is likely to be less

[40] Andreas Naun quoted in Bloomberg.com, "China targets GE Wind Turbines", 14 October 2011

[41] Woodlawn Associates, Wind Turbine Industry Opportunities, Presentation 3 Sept 2009

sensitive in the context of a large on-shore wind farm in China, in the context of an offshore application in Europe, this may place Chinese products at an initial disadvantage.

A number of major Chinese and other low cost OEMs have aspirations to offer equipment under their own brands in European and US markets. In this case, their cost bases are significantly lower than their European counterparts due to lower costs of labour and in some instances, access to lower cost raw materials or competitive finance. Currently these competitors are focused on the on-shore market. China has however set a target for 5GW of offshore power by 2015 and 30GW by 2020. Sinovel has recently won their first demonstration project for a 6MW offshore turbine.

Chinese turbine manufacturers have been successful in exporting their technology into Brazil despite high transport cost, typically $200,000 per turbine and a 17% import tariff. Sinovel is reported to have offered a 10% saving compared to Western market leaders.[42] However, other than REpower, the European-badged subsidiary of Suzlon, there is presently no active low-cost market entrants in the European off-shore market.

The potential impact of low cost market turbines on the European market can be judged from statements from Vestas, who have set out to match the costs of imported Chinese turbines (including transport costs) in local markets.

There is evidence of low-cost market penetration in support structures, where Shanghai Shenhua Heavy Industry (ZPMC) has delivered monopiles on Greater Gabbard.

This lever explores whether the entrance of new players from low cost countries is likely under the study stories and the cost saving associated with their presence in those stories where the supply centre mix includes low cost jurisdictions. Through engagement with industry, this study has considered the ability (and cost) of transporting large equipment from low cost countries to the market and has also explored the perception that sourcing from some low cost OEMs implies an opex penalty.

Possible cost reductions attributable to low cost entrants are measured against the current situation as summarised in Table 18 below.

Table 18 Current Status 2011 Low Cost Competition

2011 Baseline for Low Cost Competition.	
Turbines	Slow, low volume market with a weak pipeline of work. One dominant European player, one significant competitor. Limited immediate low cost competition entrants (Samsung).
Support structures	Sufficient capacity in monopiles (8 suppliers). One active low cost competitor partner with widely publicised quality issues.
Array cables	Competitive market for inter- array cabling at medium voltage. No immediate low cost competition entrant.
Installation	Undersupplied market. No immediate low cost competition entrant.
Planned O&M	Provided by OEMs. No immediate low cost competition entrant.
Unplanned O&M	Linked to OEMs. No immediate low cost competition entrant.

3.3 Vertical Collaboration (and Interface Risk)

Currently, contracts are mainly awarded on a project by project basis with most owner/developers adopting a multi-contract strategy.

Multi-contracting can lead to a silo approach to delivery without adequate recognition of the interdependencies between work packages. In the situation and with no turn-key solution offered, the owner/developer holds most of the interface risk. The multi-contract approach leaves buyers contractually exposed to risks (including creditworthiness) related to each supplier in the chain. With no project wrap, the weakest link is most relevant at any time. Interface risk and associated contingencies may be reduced by the following:

[42] Bloomberg.com, “China targets GE Wind Turbines”, 14 October 2011

— Consolidating procurement packages (mini-EPC) thus reducing interfaces, contingencies and cost overruns. In these cases, the supplier takes on higher levels of risk, and thus will charge a higher contract price (up to 15-20% higher). Assuming that the supplier is then well placed to manage their internal interfaces, savings will be accrued by the owner/developer because although it pays more for the installation contract, it can reduce (of up to 50%) the contingency it places on the overall project and its expectation of cost overruns. As already discussed, these savings are not reflected in this analysis as they are included in the finance work stream report by PWC.

— Improving interface management through development and implementation of programme management tools.

— Involving suppliers (designers, installers and O&M providers) early and prior to procurement in order to design risk out of solutions and avoid iterations that can result in cost overruns.

— Sharing studies, facilities and people.

This type of co-operation could be affected through contractual structures and formal partnerships or through more informal collaboration arrangements. An example of the latter is the proposal by ABLE to develop an offshore wind marine park on the Humber River, where turbine, support structure and installation specialists could collocate to minimise piece movement and transport costs. This model has been established in Europe - e.g. Bremenhaven – where two turbine manufacturers, one blade manufacturer and a monopole fabricator are collocated.

This lever explores how increased vertical collaboration may result in cost reductions against the current situation as described in the table below.

Table 19: 2011 Current Status Vertical Collaboration

2011 Baseline for Vertical Collaboration	
Turbines	Typically Round 1 and Round 2 projects in the UK are being developed using a project by project approach with involvement from the supply chain limited to when the project reaches procurement stage. Some examples exist of vertical collaboration: RWE's formal JV with Siemens on Gwent Y Mor, SSE's offshore wind alliance which includes Siemens, call-off supply arrangements in place for Gamesa with Scottish Power and Repower and RWE and initial bidding consortia established for €10bn French offshore wind programme. Emerging participant Smartwind has a vertically integrated delivery model.
Support structures	Some vertical collaboration exemplified by Strabag's JV with Northern Energy Projekt GmbH for development in the German North Sea. Bifab is a member of the SSE offshore alliance.
Array cables	Little vertical collaboration
Installation	Delivered as mini-EPC or multi-contracted as a number of packages with no overall project wrap. Although savings on developer's contingencies are reflected in the finance work stream report, the current situation assumes P90 equal to twice the contract price and an overall 10% project contingency. Examples of current vertical collaboration include: RWE is a direct investor in vessel capability, E.on and Centrica have long term vessel contract. Dong and Siemens are joint owners of vessel operator A2Sea, Subsea7 is a member of the SSE offshore wind alliance.
Planned O&M	Currently delivered as part of maintenance agreement. Little vertical collaboration
Unplanned O&M	Little vertical collaboration

3.4 Asset Growth and Economies of Scale

Making investments in supply chain development requires certainty over volumes and visibility of future order book.

The UK has a huge offshore wind resource, with a potential for up to 1940 TWh of generation.[43] The UK's current consented capacity is only about 5% of the European total forecast to 2020 (see section 2.3) with large potential volumes in the Round 3 pipeline (35GW of capacity was awarded by the Crown Estate in 2010) and the Scottish Territorial Waters (STW) projects. At

[43] The Offshore Valuation Study, PIRC 2010.

present, the majority of Round 3 projects have not reached FID as they are still going through the development phase including consent with some transmission connected offers made and accepted but detail (design and costs) to be worked on. This means that although the potential is large, there is uncertainty over total realisable volumes with only about of 5.2GW of projects in operation, construction and consented (see section 2). This means that in terms of the supply chain, the market opportunity is small and order book visibility low.

There are different private views about what installed and committed capacity might be available by 2020. In this study, a range of market volume trajectories has been stipulated as part of each 'Story' (see below):[44]

- Slow Progression (Story 1): build out rate of 1GW/yr (average) with a total of 31GW operational in Europe by 2020 of which 12GW are in the UK.
- Technology Acceleration (Story 2): built out rate of 2GW/yr (average) with 36GW and 17GW operational in Europe (including UK) and UK respectively by 2020.
- Supply Chain Efficiency (Story 3): built out rate of 2GW/year (average) with the same operational capacity by 2020 as in Story 2 (36GW and 17GW in Europe (with UK) and UK respectively).
- Rapid Growth (Story 4): built out rate of 3GW/yr (average) with a total of 42GW operational by 2020 of which 23GW are in the UK.

With certainty over higher annual and cumulative volumes, it is possible to unlock investment in the supply chain and develop new capacity (asset growth) and realise economies of scale. This lever explores how asset growth and economies of scale can result in savings and cost reductions.

Asset growth depicts the willingness of players to invest in additional production lines or manufacturing facilities, associated infrastructure such as ports and assets that have long lead times and long pay back periods such as vessels (three to four years build and 15 to 20 year pay back). As capacity increases, cost savings can be achieved through for example productivity improvements (having more vessels reduces the impact of installation delays as it affords increased flexibility) and logistics (if new capacity and its associated supply chain are located closer to the market it is possible to minimise transport costs).

Evidence of the importance of assured asset growth can be seen in investment activity by vessel operators in 2007-2008 – during which FID was reached on 10 installation vessels which will have entered the market by 2013. Not only do these vessels create greater diversity in the supply chain, but are also critical in relieving potential constraints, such as water depth, monopile size or handling of jacket foundations.

With increased volumes, economies of scale can be achieved and efficiencies obtained in:

- Procurement due to volume (rationalising suppliers and obtaining volume discounts).
- 'Learning by doing' and implementing procedures that allow repetition (doing the same in larger volumes) in a more efficient manner.
- Standardising processes/protocols thus reducing the need for more expensive bespoke solutions and serial production, standard lengths for array cables.
- 'Sweating assets' or increasing the productivity of existing assets (including manufacturing facilities) by increasing volume throughput.

Examples of volume-base procurement include the extended supply framework arrangements entered into by RWE and REPower, Gamesa and Scottish Power (10 years) and Dong and Siemens.

This lever explores how changes in asset growth and economies of scale from the current situation described in Table 20 may result in cost savings.

[44] These are based on the numbers from ODIS - National Grid's Offshore Development Information Statement, September 2011.

Table 20: 2011 Current Status Asset Growth and Economies of Scale (AG,ES)

2011 volume certainty about 5GW	
Turbines	Current 3.6-4MW turbines, some 6MW turbines already operational. 41 manufacturers have announced plans to develop 51 turbine models. There is a need to test prototypes for larger turbines, which will delay market entry. No manufacturing facilities in the UK but plans announced by Siemens and Vestas. Their production could start in 2015 if FID is taken in 2012 although both manufacturers have declared that 2GW/yr deployment rate in the UK will be necessary for them to take that decision. Current capacity can deliver 300 <5MW turbines and 100 to 200 >5MW turbines per year.
Support structures	Characterised by bespoke solutions, significant fabrication challenges, lack of standardisation and high investment. Multiple players in monopile with sufficient capacity to deliver 3GW/yr. Emerging market in jacket and tripod, with capacity to deliver 0.5 to 1GW/yr.
Array cables	Commodity product with competing markets. Sufficient capacity to meet current demand.
Installation	4/5 Installation/Balance of Plant Contractors in the market. Capacity in vessels is improving, with 10 new vessels with deep water/large turbine capability entering the market during by 2013. A number of cable installers but potential constraints due capability and financial strength of players. The majority of insurance claims during construction in the market to date have risen due to problems in cable installation.[45] Rapid growth in an immature market sector means that small companies cannot cope with the contracting issues that result from being in a high risk environment.
Planned O&M	No independent capacity in the market at present, bespoke solutions, linked to OEMs. Current OEM technology and R&D investment is aimed at achieving differentiation through improved reliability, reducing O&M requirements.
Unplanned O&M	No capacity in the market at present, bespoke solutions, linked to OEMs. No dedicated vessel capability is currently planned for the O&M sector.

3.5 Horizontal Co-operation

The competitive nature of the industry is leading to a strong IP-driven approach to the supply chain. Horizontal co-operation in the supply chain usually involves sharing of best practices and facilities and development of joint IP. It may also involve working together to develop standards and sharing between peers (for example sharing repair vessels amongst O&M operators).

Some industry experts advocate that unlike the early stages of the offshore oil and gas industry, there is little evidence of information sharing in the offshore wind industry.[46]

Examples of where existing best practice could be adopted include use of standard contracts such as the LOGIC offshore contract, existing safety management practices (OPITO) and the utilisation of existing technical standards. According to the Natural Power study,[47] the oil and gas industry has 198 industry-adopted technical standards whilst offshore wind has 3 – Natural Power claim that 102 of the existing standards could be adopted by the wind industry.

Greater sharing of experiences from other offshore industries and past projects (including construction and operational issues) would increase learning and have a positive impact on costs.

This lever explores cost reductions that may be accrued by increasing the levels of horizontal cooperation within the industry against the 2011 baseline described the table below.

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[45] From interviews and workshops

[46] UKERC, Great Expectations: The cost of offshore wind in UK waters – understanding the past and projecting the future, September 2010.

[47] Natural Power, Overcoming Challenges for the Offshore Wind Industry and Learning from the Oil and Gas Industry, February 2011

Table 21 2011 Current Status Horizontal Collaboration

General limited horizontal collaboration through industry forums such as Renewable UK	
Turbines	Horizontal collaboration limited to participation in industry forums through for trade associations such as RenewableUK. The scope for horizontal collaboration is limited by the extent to which developers and their supply chains are in direct competition. This has led to strict confidentiality policies and broad interpretations of what Intellectual Property (IP) is and a keen intention to guard it. Certain industry wide commonality of design and best practice is happening because of lessons learnt; a certain level of informal communication occurs in the offshore wind industry. As solely informal communication, the quality of the message, and understanding transmitted is limited with industry penetration being ad-hoc.
Support structures	
Array cables	
Installation	
Planned O&M	
Unplanned O&M	

3.6 Contract Form

This lever explores whether changes in contract forms/terms can lead to cost reductions. Round 1 and 2 projects have mainly been contracted on a lump sum, fixed price basis with poorly defined contract terms and inadequate incentives/penalties for performance and delays. Moving away from lump sum contracts, tightening terms and conditions and the introduction of more appropriate incentive mechanisms may lead to cost reductions:

— Typically, lump sum, fixed price contracts leave suppliers (Tier 1 and below) open to risks related to unforeseen costs, materials, programme, etc. These risks can be embodied in the contracted price in the form of a contingency sum priced to protect the supplier from unforeseen/omitted costs and possible cost overruns. Typical contingency allowances range from 15 to 20% depending on the extent of risk taken by the contractor. Contingencies flow across the supply chain and contribute to the contract price seen by developers. In turn, developers' financial models contain overall project contingencies and assumptions of likely outturn costs.

— Contract forms, such as risk sharing and target pricing, can deal with the allocation of unforeseen costs in a more transparent way. If suppliers are adequately incentivised, and the risk event does not materialise, this can reduce contingencies and lead to lower contract prices. For example, a contractor's 15% contingency can be placed on a 'contingency pot' which is then shared if not used - the contractor receives half the contingency (for example) (contract price + 7%) and the buyer pays 7% less (contract price with only 7% contingency). Increased transparency and a better understanding of risk and can allow developers to reduce their estimation of outturn costs.[48]

— Poorly defined contract terms can be open to interpretation post contract signature leading to increased management time and thus increased costs. To date, contracts have tended to be modified for each project and work package leading to lack of clarity and in cases omissions, for example, no provision for dealing with variations and rates that are not relevant, unclear exclusion clauses, undefined payment schedules and confidentiality clauses that protect 'commercial sensitive' items from providing cost justifications.

— Prices have mainly been the result of computing input costs rather than analysis of outputs. Incentivisation mechanisms have then tended to focus on controlling costs rather than maximising outputs. In some cases, Liquidated Damages (LDs) have been too low with the owner/developer having insufficient recourse on the supply chain to ensure the most appropriate behaviour. For example, in a market with high demand and short supply, LDs may not deter a contractor from supplying another site and suffer the LDs on the existing contract. In other instances, LDs have been set too high and have contributed to smaller suppliers going bankrupt (cable installers). Moving to an output driven incentivisation method may lead to a more appropriate solution and lower LCOE. For example, the use of collaborative contracts based on the NEC type of contract in the construction and oil and gas industries has encouraged partnering behaviours between the parties, contributed to the successful delivery of projects (within budget and on time) and delivered cost savings in the range of 15-45% on contracts previously let on an unincentivised time and resources basis. (See Section 4.3 for more details).

— The industry has tended to transfer risk along the supply chain through back-to-back contracts. In some instances, this has led to contract terms such as warranty levels, being set (or demanded) at lower tiers of the supply chain at inappropriate levels. For example, excessive warranty periods for installation work where no goods or material are

[48] Contract price variation is usually modelled as a normal distribution and the outturn price (worst downside) taken as the P90 value.

supplied. The work is performed and accepted within a matter of days or weeks but warranty periods of a number of years are still requested. The impact on the supplier is twofold: the price of the item needs to increase in accordance to the estimated need for repair /replacement during the warranty period (which may not be required and difficult to estimate if no goods have been provided). Secondly, the installer remains contractually tied into the project for a long period. Similarly, high LDs on small value contracts have resulted in company failure in the supply chain. Re-allocating who bears risk can help to reduce LCOE. Risk reduction within the supply chain is important if it enables supply chain contractors to reduce costs.

This lever explores how changes in contract forms/conditions from the situation described in Table 22 may result in lower contract prices. This lever does not include changes in contingency levels and outturn costs as experienced by the owner/developer as these are considered by the finance stream.

Table 22: 2011 Current Status Contract Forms

Current Situation for Contract Forms	
Turbines	Currently contracted using bespoke contracts (Turbine Supply Agreements) which have a lump sum fixed price, with LDs on delay for delivery and on availability guarantees. Warranty periods tend to be 5 years with the possibility for extensions.
Support structures	Contracted on a lump sum price basis with LDs on delay for delivery. Support structure supply contacts cover delivery to a hub collection point. In practice the transfer of risk has often been imperfect due to the contractual reliance upon the developers' base data for geotechnical bed conditions and the contractors' dependence upon the developers' performance. This has resulted in valid claims payable above and beyond the lump sum price. The most frequent claims arising from liabilities are for bed ground conditions, the foundations, the support structure & installation, array cable installation interface.
Array cables	Commodity product bought on a fixed price, lump sum basis. LDs for delay but not for performance as this can only be tested at commissioning stage. Cable supply contracts tend to exclude storage.
Installation	Contracted as a number of packages on lump sum fixed price contracts to cover the installation of cables, foundations, turbines and the supply of vessels. Turbine installation typically undertaken by the OEM. Other installation and BOP work either undertaken as multiple direct contracts or mini-EPC.
Planned O&M	Within the warranty period it is part of the supply contract. Currently the main option in the market is to extend warranties or obtain Long Term Service Agreements (LTA) from Turbine OEMs and BOP suppliers.
Unplanned O&M	Within the warranty period it is part of the supply contract. Currently the main option in the market is to extend warranties or obtain LTAs agreements from Turbine OEMs and BOP suppliers.

3.7 Uncontrollable Risk

Uncontrollable risks are those that cannot be predicted or insured against. This report considers the risk associated with unpredictable weather (sea state and wind) and ground conditions and consequential loss due to delays attributed to parties outside of a particular contract scope. For example, if a support structure installation package does not include the provision of vessels, unavailability of the vessels at the appropriate time will cause delays in the installation of the foundations which in turn will have other knock on effects on the schedule – delays in the installation of the turbines etc. These consequential losses can be great and difficult to recover from the party that initiated them as they tend to be larger than contractual LDs. For example, disputes over monopile quality on Greater Gabbard have resulted in delays of at least one year.

This lever also includes unforeseen costs such as those due to technology breakdowns and excludes force majeure events. Economic and financial factors such as the impact of currency fluctuations, and commodity prices, are covered in 6 of this report.

Current practise is for the supply chain to exclude uncontrollable risk from its scope. This means that the owner/developer takes all the risk associated with delays to generation or stranded assets due to uncontrollable factors through contingencies and an estimation of the potential impact on outturn costs (P90). A better understanding and apportioning of uncontrollable risk can accrue savings by reducing their impact. For example, unforeseen ground conditions can be mitigated by gathering greater understanding of the seabed prior to installation. Weather risk could be better mitigated by investing in vessels that can operate in greater swells and also through long term agreements as weather patterns tend to even out over a period of time. Longer terms contracts (covering a number of installation cycles or a programme of projects) can also ameliorate the impact of downtime due to breakdowns (spreading their impact over a longer period) and result in better optimisation of resources (sharing vessels across projects and/or installers and sharing spares). Also, as installation methods evolve and more work is undertaken offshore, it will be possible to reduce the contingency set aside for weather risk.

This lever explores whether it is possible to reduce and/or re-locate uncontrollable risk in order to reduce LCOE against the current situation defined in Table 23.

Table 23 2011 Current Status Uncontrollable Risk

2011 Uncontrollable risk currently excluded from supply chain contracts and held by the Owner/Developer.	
Turbines	Weather risk is only relevant as far as delivery to hub collection point and tend to excluded from contracts. Ground conditions not relevant. Other unforeseen costs are embodied in the contract supply price.
Support structures	Weather risk is only relevant as far as delivery to hub collection point and tends to be excluded from contracts. Ground conditions excluded from supply contracts. Other unforeseen costs are embodied in the contract supply price. As explained under contract forms, this risk transfer has been imperfect due to the contractual reliance upon the developers' base data for geotechnical bed conditions and the contractors' dependence upon the developers' performance.
Array cables	Not relevant.
Installation	Weather and ground conditions tend to be excluded from all installation packages as well as consequential loss due to delays attributed to other parties outside of the contract scope. Other unforeseen costs are embodied in the contract supply price. All interface risks held by developer in multi-party arrangement.
Planned O&M	Weather and ground conditions tend to be excluded. Other unforeseen costs are embodied in the contract supply price.
Unplanned O&M	Weather and ground conditions tend to be excluded. Other unforeseen costs are embodied in the contract supply price.

4 Supply Chain Cost Reduction Pathways: Story 3

4.1 Introduction

This section presents the supply chain cost reduction pathways for Story 3: Supply Chain Efficiency. As indicated in Section 1 of the report, the Supply Chain Efficiency Story has been used as our central case as it provides the most suitable evolution of the current situation for maximising supply chain benefits. The other stories (1, 2 and 4) are variants of the central case.

The cost reduction pathways presented in this section correspond to the supply chain impact on the capex and opex elements of the Study's 2011 cost baseline highlighted in blue in

Table 2 and reproduced below[49]:

- Turbines: £1,024k/MW
- Support structure (including tower):£551k/MW
- Array electrical: £80k/MW
- Installation (covering turbines, support structures and cables): £473k/MW
- Planned Operation and Maintenance: £26k/MW/yr
- Planned Operation and Maintenance: £53k/MW/yr.

The proposed reductions are net of investment costs and represent a base case scenario as they do not consider fluctuations in currency and changes in commodity prices. These issues and their impact on the supply chain's ability to achieve the proposed savings are explored in Section 6 of this report.

4.2 Story 3 by Cost Element

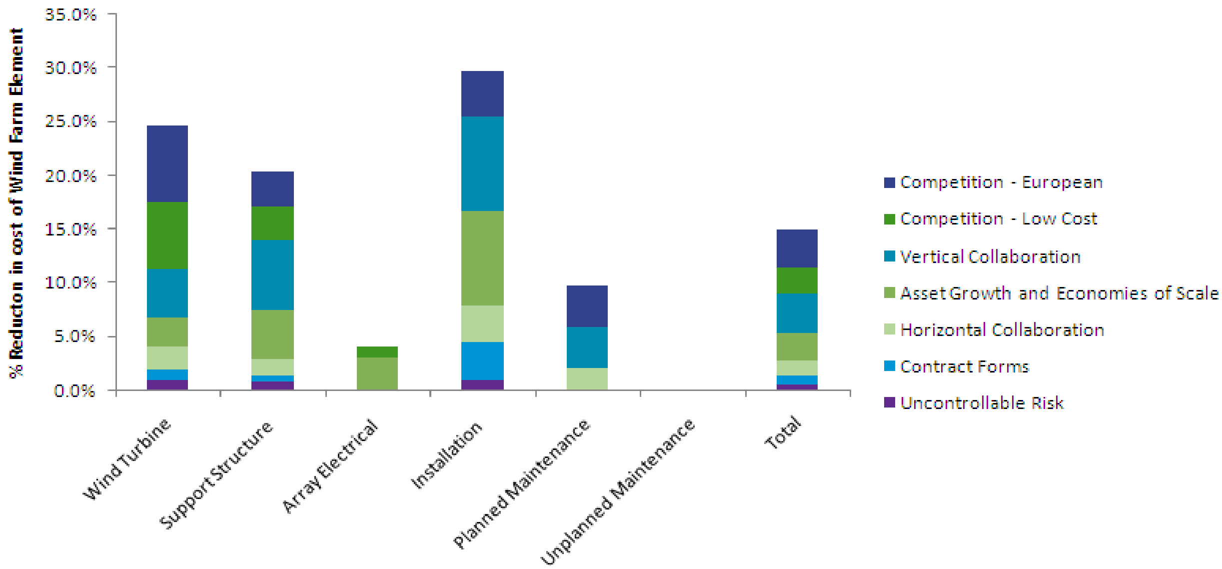
The Supply Chain Efficiency Story is characterised by incremental evolution of technology with 4 and 6 MW turbines dominating the market and becoming increasingly reliable. The supply chain is able to mature and exploit efficiencies and the depth of financial markets increases over 2011 levels. All these result in the UK market reaching 17GW of operational projects by 2020 (36GW in Europe including UK) with a deployment rate of 2GW/year (average).

The cost reduction pathways identified through discussions with industry are summarised in Figure 13. The figure shows that by FID 2020, the largest potential for supply chain capex reductions is in the installation cost element, followed by wind turbines and support structures. Significant savings were estimated in the costs of O&M but these are only likely to be realisable post FID 2020.

Each of the cost saving opportunities is discussed per wind farm element in turn below.

[49] The 2011 baseline refers to 4MW turbines located in Site A and it does not include overall project contingencies.

Figure 13: Story 3: % Reduction on Costs over 2011 Cost Baseline per Wind Farm Element

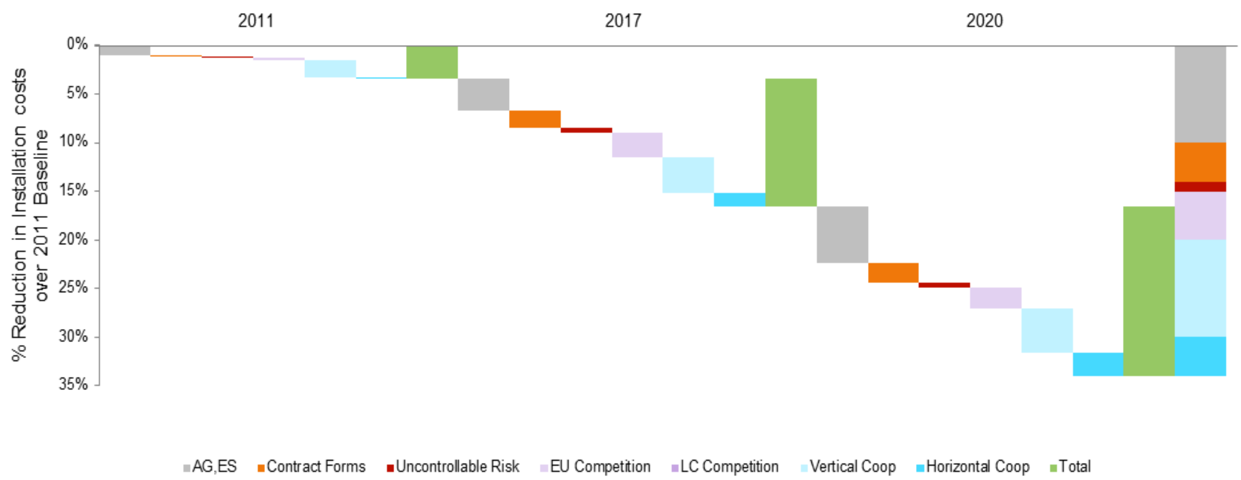


4.3 Installation

As can be seen from Figure 14, the supply chain may be able to reduce the 2011capex for installation by 30% by FID 2020 under Story 3. Industry suggested that that the proposed cost reductions were mainly driven by the following:

— Asset Growth and Economies of Scale (10%): The proposed cost reductions result mainly from spreading investment of long lead items, such as vessel construction and port development, over longer periods and through increased productivity from greater volumes and standardisation of practices. This includes higher utilisation of existing assets (sweating the assets thus spreading fixed overheads over more utilisation days) and confidence to build more 'modern, state of the art vessels and equipment' which will work more efficiently – e.g. increased carrying capacity and multi-functional capability. There is a need for the supply chain to develop and invest in new vessel types to address the increasing requirement to install jacket / tripod foundations and associated pin piles for these structures as the market will move from 90% monopiles at the moment to predominantly space frame foundations by 2015. The choice and adequate supply of vessels specifically designed to efficiently install these foundation types will be critical in ensuring that the increased competition lever is still applicable for foundation installation.

Figure 14: Story 3: Installation savings



— Another area of significant potential for cost savings was identified under the Vertical Cooperation lever (10%). The industry proposed that costs could be lowered by the reduction and/or better management of installation interfaces and through long term relationships and upfront involvement. Owner/developers' ability to bring installers into the planning stage of projects, either through strategic alliancing, vertical integration and/or an informal basis, was perceived as essential as well as the need for new players to enter the market with different skills and stronger financial profiles. With developers either developing vessels (RWE), taking an owner interest in Vessel Operators (Dong Energy) or agreeing long-term contracts (Centrica and E.on), this pre-requisite is increasingly in place.

— Competition (5%): As explained in Section 2, the current market is experiencing constraints in installer availability. New entrants might include other sector installation players such as those from Oil and Gas, independent specialists and vertically integrated owner/developers. As they enter the market it is expected that increased choice will drive competitive bidding. Also new players will offer different installation solutions, specialised vessels and crew and bring skills that increase efficiencies. Greater levels of competition will put pressure on the pool of skilled labour available and the industry expressed concerns that the forecasted cost reductions may not be achieved unless prompt action is taken on training and on reducing attrition rates to other more lucrative industries, such as Oil and Gas.

— Horizontal cooperation (4%): The industry believes that there is significant scope for savings through information and asset sharing. In the oil and gas industry, savings of around 30% have been achieved through a range of initiatives including industry collaboration. These expectations have been factored down to reflect the level of immaturity of the offshore wind industry and perceived need to protect Intellectual Property.

— Contracting (4%): The industry indicated that moderate cost savings can be achieved with a move away from lump-sum contracts towards incentive and performance-driven contracts, as undertaken by other industries (construction and oil and gas). A reassessment of contract terms (level of warranties and liquidated damages) was also suggested as the supply chain believes some terms have been transferred from the onshore wind industry and lack relevance in the offshore wind market.

A summary of the proposed cost reduction by levers is provided below.

Table 24: Installation Summary

Installation	
Summary	
Lever	**% Cost Reduction[1] (FID 2020)**
Competition European	-5
Competition Low Cost	-0
Vertical Collaboration	-10
Asset Growth & Economies of Scale	-10
Horizontal Collaboration	-4
Contract Forms	-4
Uncontrollable Risk	-1
Compounded Total	-30[2]

Notes: (1) % Cost reduction of cost element from 2011 baseline costs of £473k/MW and net of investment costs.
(2) Calculated by multiplying all the numbers. The total is subtracted from 100% to present the total savings.

Detailed analysis of installation cost reduction pathways is presented in Table 25.

Table 25: Installation Supply Chain Cost Reduction by Lever

Installation Supply Chain Cost Reduction by Lever	
Competition from European players	
2011 Situation	Undersupplied market with three to four contractors capable of delivering mini-EPC solutions. This means that competitive pressures are weak. Sufficient supply of vessels for turbines and foundations as a result of new capacity entering market – including 12 vessels with >5MW capacity, large jacket and deep water capability (45m) by 2013. Constraint in quality and financial strength of cable installers with specialised vessels.
2020 Situation	Mature market with contractors from offshore wind, oil gas and general civil contractors, Sufficient supply of vessels sized for all turbines types and mature market in cabling installations.
2020 % Cost Reduction	-5%- From 2011 Baseline £473k/MW

Justification

By FID 2020 there will be a well-diversified contracting market. This will mitigate the current situation of undersupply. New entrants might include other sector installation players such as those from O&G, independent specialists and owner/developers as they vertically integrate into vessel development as a means to secure availability. As new players, including utilities, enter the installation market, they will offer a number of different installation solutions and bring skills that will allow optimisation of the installation process reducing costs by minimising inefficiencies. For example, it is envisaged that large O&G installers may be able to optimise practises such as vessel and staff utilisation across offshore work (O&G as well as wind). It is also expected that they will have large balance sheets and a risk profile acceptable to owner/developers and the financing community.

Increased competition will put pressure on the pool of skilled labour available. Horizontal collaboration (see below) will mitigate the risk of labour attrition across industries (in particular the O&G industry).

Timeline

Impact from FID 2014 and linearly to 2020 as new entrants with new vessels expected by FID 2014. Larger players offering larger packages will impact the market from FID 2017.

Pre-requisites

— Assurance of volume.

— Installers in the market with the right skills and balance sheet.

— Availability of skilled labour.

— Availability of vessels.

Evidence

Refer to section 2.8 for evidence base for 2011 situation including details of current and anticipated capacity and likelihood of establishment of competitive conditions in the installation market.

The effectiveness of open competition in construction markets is demonstrated by the long term relationship between contractors' tender prices and contractors' input costs measured by the Building Cost Information Service (BCIS) of the Royal Institution of Chartered Surveyors (RICS).[50] Over the period 1976 to 2008, which covers three business cycles – including bouts of high competition during recessions, the differential between tender prices and input costs were as follows:

— Tender prices – 5.3% per annum.

— Input costs – 6.6% per annum.

The period used measures trough to peak.

Whilst the exact inflation differential may not be applied to specific aspects of the installation market such as vessels, installation contractors are more likely to secure their work via a competitive procurement process where similar pressures related to workload and capacity will apply. There is no specific measure of relative inflation in the offshore industry. This BCIS measure can be used as a proxy.

Competition from Low Cost Jurisdictions	
2011 Situation	No immediate low cost competition entrant.
2020 Situation	No significant presence from low cost installers.
2020 % Cost Reduction	0% - From 2011 Baseline £473k/MW

Justification:

Industry indicated that it is unlikely that installers from low cost jurisdictions will enter the UK market by FID 2020 for the following reasons:

— It is not cost effective to optimise the charter of vessels for such long distances.

— It will be difficult to obtain work permits for the crew.

— The crew will need to be trained to UK/European standards, including health and safety.

There are organisations like Great Offshore (India) that plan to supply vessels and services into the market but they are likely to work under European installers. Far Eastern turbine suppliers may undertake their own installation but their impact will be limited as there are unlikely to be more than two of these participants (see the section below on Turbine Competition), they may

[50] Sources: Tender Prices – BCIS All in Tender Price Index, Input Costs – BCIS General Building Cost Index

not undertake their own installation and turbine installation is only a fraction of the overall installation price.	
Vertical Cooperation	
2011 Situation	Delivered as mini-EPC or multi-contracted as a number of packages with no overall project wrap. Although savings on developer's contingencies are reflected in finance work stream report, the current situation assumes P90 equal to twice the contract price and an overall 10% project contingency. Examples of current vertical collaboration include: RWE is a direct investor in vessel capability, E.on and Centrica have long term vessel contract. Dong and Siemens are joint owners of vessel operator A2Sea, Subsea7 is a member of the SSE offshore wind alliance.
2020 Situation	The benefit of early involvement is understood and utilised widely with vertical interface risks better managed. By FID 2020, there is a mix of options in the market with some installers offering large fully rapped EPC packages and with some owner/developers still managing numerous interfaces. Developer's perception of outturn costs decreases and P90 values and overall project contingencies are lowered.
2020 % Cost Reduction	-10% - From 2011 Baseline £473k/MW

Justification

Industry view's is that significant savings in installation costs over the 2011 cost baseline may be achieved by a combination of the following:

— Increasing the size of the installation packages and thus reducing the number of contractual interfaces.

— Involving installers in the planning stage of projects.

Reduction of interfaces

The future for contracting types is currently unclear although a tendency for developers to contract larger packages of work to 2 or 3 contractors has been noticed. The supply chain is keen to provide larger installation packages reducing the number of interfaces managed by the owner/developer. In these cases, the installer takes on higher levels of risk, and thus charges a higher contract price. Savings can be accrued by the owner/developer because although it pays more for the installation contract, it can reduce (by up to 50%) the contingency it places on the overall project and its expectation of cost overruns. (As discussed, these savings are not reflected in this analysis as they are included in the finance work stream report by PWC).

Based on discussions with industry, it is unlikely that, by FID 2020, more than 25% of the market will move to an EPC approach with a significant number of reduced interfaces.

It also is likely that owner/operators and the supply chain will learn and develop tools to manage interfaces more appropriately thus allowing them to obtain cost benefits without a major change in the contracting strategy. Accordingly, cost savings could come not just from managing less interfaces, but simply by managing them better. Also, as installation methods evolve and more work is undertaken onshore, the management of interfaces will be easier, and thus less costly, and its impact on outturn costs less significant. Again allowing participants to reduce contingencies.

Early involvement of installers in the planning stage

Industry suggested savings of up to 30% by avoiding the 'If only' effect. Similar experiences and levels of savings can be found in the O&G industry where it is common practise to involve installers in the pre-FEED and FEED stages. These savings stem from, for example, the following:

— Better understanding of the impact of seabed conditions on installation methods.

— Joined up scheduling.

— Optimisation of designs (Technology saving). This may lead to interfaces being designed-out.

— More appropriate sequencing of tasks.

— Optimisation of logistic support.

— Optimisation of foundations (technology saving).

— Adequate account of health and safety implications.

— Moving from a project focus to a programme management approach.

— Minimisation of claims.

— More appropriate apportioning of risks.

Long term relationships and early involvement can be obtained in a number of ways: contractually through, for example, strategic alliancing, through vertical integration by 'buying into' other supply chain tiers (such as owner/developers purchasing installers and installation vessels or forming Joint Ventures) and/or informally. Industry suggested that in a market with sufficient volume and levels of competition, parties would be willing to collaborate upfront at risk as this would improve their position to win work later either in the same project or another. This is common practice in other industries such as oil and gas.

Industry's view is that by FID 2020 the market will present a combination of installation options, with some installers offering large packages (and higher contract prices) and with some developers still managing numerous interfaces. The level of savings suggested of 10% over the 2011 baseline represents a blended result by FID 2020 from:

— 25% of the installation market offering a 15% higher price to account for taking more interface risk and thus representing a 3.75% price increase.

— Overall, the supply chain achieves 30% cost reductions by early involvement but these savings are tempered down to 15% to reflect the savings due to technology change that are accounted for by the technology work stream.

Timeline

The 10% reduction will start from 2017 linearly until 2020. Savings due to early involvement will not be seen until FID 2017 as projects reaching FID in 2014 are undergoing planning now. The counter effect due to increased prices as installers offer larger packages will again start in 2017 as it depends on new entrants (see Competition lever).

Pre-requisites

— Owner/developer's ability to encourage early involvement.

— New players in the market with the right skills and balance sheet to manage installation risk.

Evidence

A number of alliance structures are in place in European Offshore Wind, including the SSE offshore wind alliance, and the bidding consortia led by GDF Suez, EDF Energies Nouvelles and Iberdrola for phase 1 of France's offshore wind development.

A developer reported a preference for long term alliance relationships as opposed to frameworks, but no cost reduction contribution was identified.

An assessment of the potential opportunities of vertical integration of installation with turbine and supporting structure assembly was set out in a study by Corus UK (now Tata Steel) - proposing the integration of the offshore installation of foundation, turbine and tower into one shore-based process. The calculated saving was £100,000 per foundation. Under the alternative methodology, the tower and turbine could be attached to the foundation onshore and then installed in a single operation. A number of similar approaches to maximising the extent of on-shore fabrication were developed as part of the Offshore Wind Accelerator Programme, and are proposed by installer/support structure specialists such as Strabag.

Many of the cost reduction drivers identified in by the Oil and Gas industry in the CRINE and OGITF initiatives relate to changes in specification, greater standardisation and rationalisation of design codes. Aspects of Oil and Gas innovation which relate to the installation element focus particularly on the development of the integrated services model of contracting. The integrated services model is similar to the mini-EPC/bundled contract approach adopted on an increasing number of offshore wind developments. With respect to Oil and Gas, an integrated services contract would bundle drilling and cementing contracts together with a number of associated service contracts such as measurement alongside consumables contracts for drill bits and others. The incentivisation model is described in contracts below. According to Wood McKenzie [51], the integrated services

[51] Wood McKenzie, North Sea Report 262, 1995

approach secured a 40% saving in oil field operating costs when comparing post 1995 developments with legacy fields.

An equivalent integrated services model for offshore wind installation contracts would involve the sharing of vessels by different specialist contractors involved in the installation process, together with the sharing of on-shore resources. Approaches to on-shore collaboration are discussed in greater detail in connection with turbines and support structures. (Details of CRINE and OGITF initiatives are set out in detail in Appendix B: Oil and Gas Case Study).

Additional examples of vertical collaboration relevant to the installation phase come from HM Treasury's Infrastructure Cost Review [52] which identifies the client driven adoption of logistics hubs and consolidation centres on major projects including Heathrow Terminal 5 and the 2012 Olympics as a major contributor to improved performance. No indication of cost reduction has been given.

Crossrail has adopted a form of Early Contractor Involvement termed 'Optimised Contractor Involvement'(OCI) to deliver on its key performance metric of best affordable value. OCI is intended to involve the supply chain in the finalisation of design and delivery plans in a way that is best suited to the needs of specific work packages to deliver better solutions and improved value for money. Crossrail's routes to value include: value engineering and elimination of over-specification, improved management of construction risks and health and safety issues, together with the creation of integrated teams.

Asset growth and economies of scale	
2011 Situation	Capacity in vessels is improving, with 10 new vessels with deep water/large turbine/jacket capability entering the market by 2013. There are a number of cable installers but potential constraints due to poor quality and the financial strength of some players. The majority of insurance claims during construction in the market to date have risen due to problems in cable installation. Rapid growth in an immature market sector means that small companies cannot cope with the issues that result from being in a high risk environment.
2020 Situation	Mature market with contractors from offshore wind, oil gas and general civil contractors, Sufficient supply of vessels sized for all turbines types and mature market in cabling installations.
2020 % Cost Reduction	-10% - From 2011 Baseline £473k/MW

Justification:

Industry view's is that significant savings in installation costs may be achieved by a combination of the following:

- Assured pay-back on investment on long lead items such as vessels and port infrastructure. If these investments can be spread over a longer period through longer term contracts (5 to 7 years), contract prices can be dropped by around 27% in the case of charters for installation vessels (for turbines and foundations) and up to 20% in the case of port facilities. Centrica, for example part-funded the refitting of an MPI installation vessel to increase its lifting capacity. Charter savings represents a 4% reduction in the overall costs of installation and the latter about 0.8%. Similar cost reductions (in the order of 4%) may be achieved with long term chartering of cable installation vessels.
- Continuity of work. A vessel operator described in a structured interview how installation productivity on a project improved by 25% over two seasons by retaining the same vessel and installation crew on a large wind farm project.
- Standarisation of the industry: this will allow increased productivity of assets and labour. For example, savings can be obtained by reducing bespoke, project specific deck spread design and fitting, which currently takes up to 3 weeks of

[52] HM Treasury and Infrastructure UK, Infrastructure Cost Review: Main Report, 2010.

vessel time, using common fastening methods for turbines and foundations would speed up installation by 2 to 3 hours per turbine. More standardised vessels would also save handling time at ports. Labour savings may also be achieved by increasing the multi-discipline nature of vessel crews, particularly in foundation installation where it may be possible to reduce the number of skilled labour required on board vessels by approximately half, if staff were able/allowed to cover a number of disciplines. This alone would represent a cost reduction of the overall cost of installation costs of about 1% but would require training and acceptance by clients (see Horizontal Cooperation lever below).[53]

— The industry also expressed the view that, in order to ensure savings, it would be necessary to invest in the right tools and equipment for installation. For example, vessels with better foul weather capability, able to operate through the whole year would increase productivity by installing two foundations per week in fair weather and 1 foundation during the winter. Using specialised vessels will also reduce time and achieve savings. For example, vessels with dynamic positioning (DP) have been demonstrated to offer efficiency savings of up to 50% in cable installation.

Industry's view was challenged and factored down to a 10% cost reduction over the 2011 base line of £473k/MW based on the fact that not all cost saving opportunities may be realisable as they depend on the owner/developers ability to offer long term contracts and on horizontal cooperation. Moreover, changes accrued as a result of technical innovations in vessel design have been captured by the technology stream and thus are not reflected in the savings proposed in this study.

Timeline

Main savings will be seen from FID 2017 and then linearly to 2020. This is because unlocking the benefits from asset growth and economies of scale will take up to four years (new bespoke installation vessels take up to four years to build from FID). Other productivity improvements such as increased labour efficiency could start to be felt from FID 2014.

Pre-requisites

— Visibility of volume to allow investments, particularly as infrastructure development (including vessels) is a long lead item. This means that FID for such investment needs to be made well (3-4 years) before it needs to be commissioned in the field.

— Five (to seven) year contracts.

— Sufficient number of skilled staff available.

— Training available for installation staff.

— Changes to vessels/equipment used.

— Engagement of the finance community in order to understand the funding requirements of the supply chain.

Evidence

Refer to Section 2.8 for evidence base for 2011 situation including details of current and anticipated capacity. The significant investment that has occurred in the commissioning of new vessels for delivery in 2010 to 2012 is evidence that the industry will respond with significant investment to these expectations with respect to sustained volumes of workload.

HM Treasury's Infrastructure Cost Review [54] identifies instances where cyclical work patterns have resulted in increased costs,

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[53] The cost of labour in installation represents about 20% of the total costs with 1/3 assumed for foundation installation.

[54] HM Treasury/Infrastructure UK ibid.

and where certainty over workload has driven additional savings:

- The 5 year cycle related to price control review in the water industry and other regulated utilities is claimed to result in 10-15% cost inefficiencies related to uneven workflow and the short duration of frameworks. Some regulators are adopting longer frameworks in response to this challenge. Ofgem is introducing an 8 year review period as part of the RIIO determination for UK gas distribution businesses.
- Increased workload and long term certainty around volumes of work have enabled contractors on the Birmingham Highways Maintenance PFI to secure 10% savings in road maintenance materials.
- Welsh Water have established a strategic alliance of client, contractor, sub-contractors and regulator which is claimed to have delivered 26% cost reductions on capex in the most recent cost review period.

Horizontal Cooperation	
2011 Situation	Horizontal collaboration limited to participation in industry forums through trade associations such as RenewableUK . The scope for horizontal collaboration is limited by the extent to which developers and their supply chains are in direct competition. Certain industry wide commonality of design and best practice is happening because of lessons learnt; a certain level of informal communication occurs in the offshore wind industry. As solely informal communication, the quality of the message, and understanding transmitted is limited, with industry penetration being ad-hoc.
2020 Situation	Horizontal cooperation developing but still the benefits not fully exploited.
2020 % Cost Reduction	-4% - From 2011 Baseline £473k/MW

Justification

The industry believes that there is significant scope for savings through collaboration towards common outcomes and sharing of information, labour, vessels ('time share' to reduce vessel downtime) and port facilities. If vessels and equipment are shared across projects and across companies, installation productivity can improve as work can take place in a constant stream reducing downtime and bottlenecks. Marine parks are an example of increased collaboration leading to savings as common elements could be shared across different participants (transport, communications, tools, spares).

In the oil and gas industry savings of over 30% are claimed to have been achieved through industry collaboration. In labour alone, the oil and gas and nuclear industries provide useful examples where 14% and 17% saving on labour costs were achieved and cost escalation mitigated through equalisation of rates across the sector.

These significant cost savings expectations have been factored down to 4% to reflect the level of immaturity of the offshore wind industry (when compared to oil and gas and nuclear for example). 4% is considered realistic as if only rate equalisation was to be implemented; labour savings would represent 3% of the installation element. This activity could be coordinated, for example, through the Offshore Contractor Association (OCA).

Timeline

The impact of these savings could be felt from FID 2014 and then linearly to FID 2020.

Pre-requisites

- Availability of training courses which are applicable across a number of installation solutions and technologies.
- Ability of owner/operator to encourage cooperation.

Evidence

Many of the cost reduction drivers identified in by the Oil and Gas industry in the CRINE and OGITF initiatives relate to changes in specification, greater standardisation and rationalisation of design codes that are driven by horizontal cooperation. Relevant examples for the installation element include:

- Greater standardisation of components, reducing learning curves associated with different installation processes and requirement for a less-skilled workforce that does not have to adapt working methods for each successive project.

Evidence from CRINE suggests that installation savings of up to 25% could be achieved through use of standard components if interfaces are simplified and operatives became more familiar with standard parts.

Cross industry applications which increase efficiency of off-shore working. Examples of high-impact initiatives developed under OGITF include: (Details of CRINE and OGITF initiatives are set out in detail in Appendix B: Oil and Gas Case Study)

- Industry standard contracts. The standard LOGIC contract has been adopted for 70% of Oil and Gas projects. One developer estimated that bespoke contracts on offshore wind projects typically cost £2 million in total.
- Vantage POB. A personnel tracking system that reduces the costs of offshore personnel safety monitoring. This will facilitate the shared use of vessels, where monitoring of operative safety is less direct than on land. Vantage POB currently monitors 1 million personnel movements per annum on the UK Continental Shelf.
- Industry Mutual Hold Harmless. (IMHH) A contractual arrangement which facilitates co-working by limiting liability associated with accidents or damage to assets. IMHH reduces the need for duplicate insurance and simplifies resolution of insurance claims.

Contract Forms	
2011 Situation	Contracted as a number of packages on lump sum contracts to cover the installation of cables, foundations, turbines and the supply of vessels. Turbine installation typically undertaken by the OEM. Other installation and BOP work either undertaken as multiple direct contracts or mini-EPC.
2020 Situation	Move towards performance related contracts based on outcomes rather than costs with alliance contracting and framework agreements. Also, more flexible approach in contractual obligations so risk is allocated to those best able to manage it.
2020 % Cost Reduction	-4% - From 2011 Baseline £473k/MW

Justification

The cost reductions put forward by industry represent a combination of the following:

— Streamlining contracts with risk reward sharing could reduce costs. This would signify a move away from the current practise of lump sum price contracts to performance related contracts based on outcomes (such as installation timing) rather than costs. This transition has been seen in other industries (construction, oil and gas and others) with cost savings ranging from 10% to 45% as a result of incentivising contractors and aligning objectives. This applies to the installer who would then need to optimise the sourcing of their vessels.

— There is also an appetite for alliance contracting and framework agreements as these would allow visibility of pipeline, volume procurement of materials and optimisation of vessels across a programme of work rather than individual projects. These contracting forms would need to include adequate benchmarking and KPIs to ensure that price pressure is placed on the contracting supply chain. The benefits from this type of contracts have been captured under the Vertical Collaboration lever (and so are not included here).

— Providing a more flexible approach in contractual obligations so that risk is allocated to those best able to manage it. This includes a reassessment of contract terms in particular the level of warranties and liquidated damages that are demanded from the supply chain. Industry argued that some of these terms have been transferred from the onshore wind industry and lack relevance in the offshore wind market. This is indeed the case in the oil and gas industry where shorter warranty periods (two years instead of five) and lower liquidated damages (20% of contract price rather than 100%) are acceptable. This modification of contract terms would need to be accepted by the financing community and insurers.

Cost savings were factored down from those seen in other industries (between 10-45% claimed in the construction and O&G industry) as those include other issues such as increased collaboration which offer benefits beyond those involved in altering contract forms.

Timeline

Cost reduction through changes in contracting will start to be seen from FID 2014 with greater impact from FID 2017 as some FID 2014 projects are already under contractual discussion.

Pre-requisites

Greater understanding by the financing community, insurers and due diligence advisors about risk and its most appropriate allocation across the supply chain.

Evidence

Over the past 20 years, the construction industry has altered its approach to contracting for large projects significantly following the publication of the Latham and Egan Reports. These reports were instigated by the recognised need to move away from the adversarial contracting arrangements that frequently resulted in poor performance, claims and litigious behaviours, delayed projects and significantly increased costs. Key changes adopted by the industry are summarised below:

- Newer and revised forms of standard contracts with common goals with more integrated work across the supply chain to achieve those goals. Partnering and alliance contracts developed from these arrangements in which all parties became incentivised to meet the project specific objectives. Contract variants include the NEC suite of contracts, PPC2000 and the JCT Collaborative Contract.
- Standard contract forms developed with KPIs in order to improve visibility between the parties and to actively drive continuous performance improvements within and between projects and programmes of work.
- Move towards different methods of payment, from more traditional lump sum and re-measurement contracts, payment methods have altered to financial risk-sharing arrangements such as cost reimbursable, target cost, schedule of rates contracts under framework conditions that secure long term benefits for both client and suppliers and contractors. Lump sum, guaranteed maximum payment and re-measurement options are still used but generally within a more collaborative style of contract.

These changes have collectively led to cost reduction in the order of 15% (based on EC Harris's experience).

Evidence from the Oil and Gas industry suggests that standardisation of contracts and pre-qualification, together with a shift towards, incentivised, output-orientated contracts has been an important enabler in driving wider performance improvements associated with collaborative working. In this context, the incentivised contract is typically focused on a measurable, timebound deliverable, such as a well which meets acceptance criteria and programme requirements. Incentivisation could be a combination of early completion bonus and pain/gain share on price assessed against an agreed target price.

Uncontrollable risk	
2011 Situation	Weather and ground conditions tend to be excluded from all installation packages as well as consequential loss due to delays attributed to other parties outside of the contract scope. Other unforeseen costs are embodied in the contract supply price. All interface risks held by developer in multi-party arrangement.
2020 Situation	The impact of uncontrollable risk mitigated by better understanding and apportioning of uncontrollable risk.
2020 % Cost Reduction	-1% - From 2011 Baseline (£473k/MW)

Justification

Uncontrollable risk is highest during installation as sea state and ground conditions, as well as vessel breakdowns, have a significant impact on installation schedules and programmes. Cable installation has been an area of particular difficulty where there have been examples of significant cost overruns.

As explained in Section 3, uncontrollable risk tends to be excluded from all installation packages and managed by the owner/developer through a contingency and an estimation of the potential impact on outturn costs (at P90).

A better understanding and apportioning of uncontrollable risk can accrue savings. Based on experience in the oil and gas sector, the supply chain believes that risks classed as 'uncontrollable' could be made more controllable - gathering greater understanding of the seabed prior to installation, investing in vessels that can operate in greater swells, smoothing out the impact of weather and breakdowns over a longer period, optimising resources (sharing vessels across projects and/or installers and sharing spares). Greater co-operation between consortia both across installation and O&M of the assets will increase utilisation and mitigate the impact of uncontrollable risks. Also, as installation methods evolve and more work is undertaken offshore, it will be possible to reduce the contingency set aside for weather risk.

There is a belief that many projects suffer from overlapping insurances between contractors, and optimisation of this element could deliver savings in the near term.

These savings will be reflected in two ways:

- It was felt that the largest reduction in uncontrollable risk would be gained through mitigating overspend. The owner/developer will experience a saving through a reduction on the overall project contingency and a lower expectation of cost overruns. These savings are not included in this analysis as they are considered by PWC in the valuation of installation risk.
- A small saving (up to 1%) can be accrued by the installer by optimising downtime. The savings may be significantly larger but they have been tempered down as some are covered under the Horizontal Collaboration lever (see above) and some are dependent on technical change (covered by the technology stream) and on the ability to obtain long term agreements (the impact of these reflected under the Asset Growth and Economies of Scale lever above).

Timeline

The impact will start from 2014 assuming that:

- Owner/developers are willing to allow the supply chain to take appropriate risk and offer long term contracts.
- New entrants are available by 2014 that can manage uncontrollable risk more adequately.
- Horizontal cooperation and sharing of facilities.

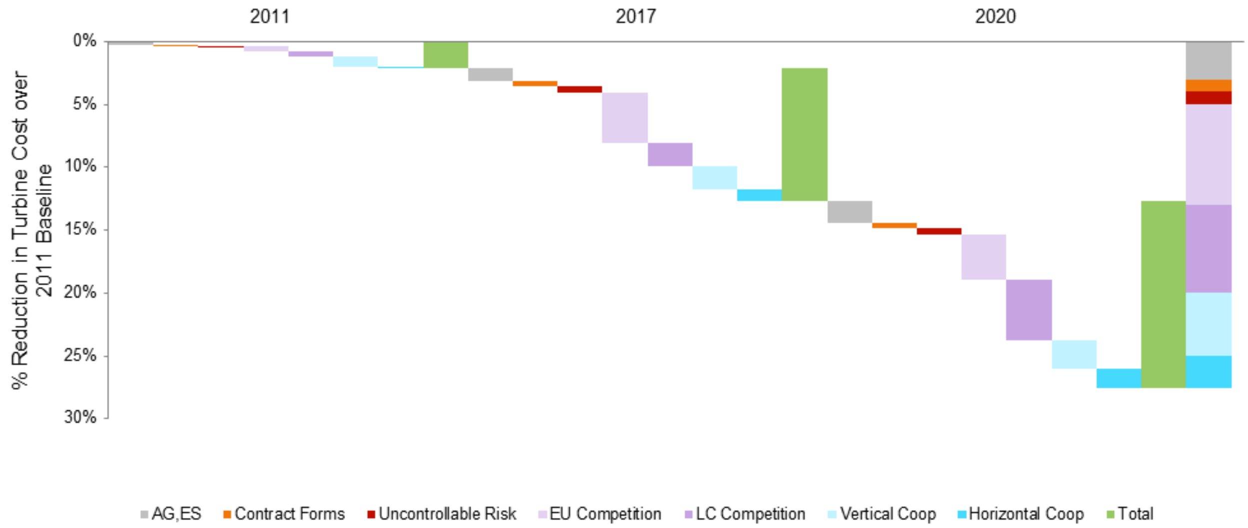
Pre-requisites

- Long term contracts.
- Installers in the market with the right skills and balance sheet.

4.4 Wind turbines

As indicated by industry, by FID 2020 there is the potential for a 25% reduction effected by the supply chain in the cost of turbines over the 2011 cost baseline (see Figure 15).

Figure 15: Story 3: Turbine savings



The main cost reduction drivers are increased competition, cooperation and economies of scale (see Table 26):

- Competition (15%) from new entrants from the EU (such as Alstom and Gamesa), and the introduction of lower cost options such as those from Sinovel, are together expected to account for over half the savings projected over the period. As such, it is vital that market volumes are assured to stimulate the introduction of these groups. Early opportunities to deploy and demonstrate new solutions will be vital to build momentum for new entrants.
- Beyond competition, vertical co-operation (5%) offers the next largest area of savings for the wind turbine rotor and nacelle, as this offers potential for increased standardisation and reduces interfaces. From a supply chain perspective and to optimise cost reductions, it was felt that the industry will require some standardisation around turbines in the 4-6MW range. If existing participants continue to evolve new, ever-larger, designs then the supply chain will not get chance to consolidate and entry costs will remain high, limiting the ability of new entrants to compete. However, the rapid deployment of the 4-6MW range, tested, demonstrated and 'bankable' will hold key to meeting the potential timelines of savings by FID 2017 and 2020.
- Asset Growth and Economies of Scale: (3%) stemming from optimisation of existing processes and locating new manufacturing facilities in the UK.
- Horizontal Cooperation (2.5%): Real savings in the long term can be realised through the emergence of a compelling rationale for manufacturers to pool resources and approaches. This however, requires greater certainty over 'run rate' that will enable suppliers to invest in manufacturing facilities accordingly rather than develop a 'one off' solution. Competitive or client-driven pressures may be will necessary to force the co-operation agenda.

Table 26: Turbine Summary

Wind Turbine	
Summary	
Lever	**% Cost Reduction[1] (FID 2020)**
Competition European	-8
Competition Low Cost	-7
Vertical Collaboration	-5
Asset Growth & Economies of Scale	-3
Horizontal Collaboration	-2.5

Wind Turbine	
Summary	
Contract Forms	-1
Uncontrollable Risk	-1
Compounded Total	-25[2]

Notes: (1) % Cost reduction of cost element from 2011 baseline costs of £1,024k/MW and net of investment costs.
(2) Calculated by multiplying all the numbers. The total is subtracted from 100% to present the total savings.

Detailed analysis of the installation cost reduction pathways by lever is presented in the table below.

Table 27: Wind Turbine Supply Chain Cost Reductions by Lever

Wind Turbine Supply Chain Cost Reductions by Lever	
Competition from European Players and Low Cost Jurisdictions	
2011 Situation	Slow, low volume market with a weak pipeline of work in the short term. One dominant European player, one significant competitor, 2/3 potential entrants with differentiated technologies. Greater volumes anticipated are already attracting new manufacturers.
2020 Situation	There will be a competitive market driven by 17GW of operational capacity in 2020 in UK and 36GW in Europe (including UK). The market is likely to accommodate up to six suppliers: European incumbents and new players and up to only two Far Eastern new entrants as their ability to enter the market will be limited by: — Availability of commercial products. In this respect 5 and 6MW machines are already being developed in China by, for example, Sinovel and Goldwind and UK by Mitsubishi and Samsung. — Increased demand in closer geographies which may shift market focus. For example, demand in China for offshore wind is rising (see Section 2) and Japan is reducing its reliance on nuclear energy which may see an increase in offshore wind. This means that local demand may absorb available capacity rather than directing that to foreign markets (Europe). — Far Eastern companies need to overcome logistics and the cost of transport. In order to remain price competitive in Europe, labour and cost of materials need to be significantly lower than in the West. Evidence of Sinovel entry into Brazilian markets and use of some Chinese products in the European offshore wind sector (gearboxes, monopiles) suggests that this barrier may be less significant than previously considered. [55] — Lack of track record in Europe and perceived performance penalties in particular for Chinese products and suppliers. This is a specific issue with regards to project funding which may in turn be addressed by Chinese manufacturers bringing their own sources of low cost finance to projects. In this respect, it is essential that Far Eastern companies gain access to testing sites in order to prove themselves and develop track record. XEMC Darwind, a Dutch/Chinese turbine JV installed prototype turbines in both Europe and the Far East during summer 2011. Low-cost manufacturers will also need to establish O&M and service infrastructure, which may create further barriers to entry.[56]
2020 % Cost	-8% from European players

[55] Bloomberg.com, October 2011, ibid

[56] Frost and Sullivan, An ill wind blows on China's turbines industry, 14 December 2011

Reduction	-7% from Far Eastern Jurisdictions From 2011 Baseline (£1,024k/MW)

Justification

Increased competition will allow the following:

- European and Far Eastern entrants will cause a margin compression and a more efficient supply chain through a tightening of the cost base by, for example, rationalising procurement and a placing of pressure on sub-component suppliers. It is also possible that in the short term prices may increase as there is more demand for component parts amongst turbine suppliers, but over time the costs will reduce overall as competition makes an impact.
- Competitive tendering will drive down costs. Steps to establish product differentiation by manufacturers are likely to be aimed at the reduction of LCOE - increasing the choice of investment options available to buyers.
- Story 3 assumes that the turbine market is dominated by 3.6-4MW and 5-7MW turbines. This was considered to be key to driving costs down as it ensures that the market is less fragmented (suppliers for only two size turbines rather than four or more different size machines), it reduces barriers of entry (less products to move from prototype to commercial operation) and it allows the supply chain to mature.

Timeline

The impact from competition is to increase significantly from 2017 when new turbines are considered proven, after which competition should intensify and the savings increase.

Pre-requisites

- Consented capacity is key, as is client groups' willingness to consider new turbine variants in the medium term. Early adoption of new turbines on current European projects suggests that this capacity can be in place if there is certainty of workload. Furthermore, as described in Section 2, Siemens, Vestas, Gamesa, Samsung, Mitsubishi and Areva have all expressed interest and have developed options to invest in UK-based production capacity. However, if new entrants have to wait until 2017 to secure orders then the lead-in time may be unattractive and investment may be directed to other markets.
- Likely to require some standardisation around turbines in the 4-6MW range. If existing players continue to evolve new, ever-larger, designs then the supply chain will not get chance to consolidate and entry costs will remain high, limiting the ability of new entrants to compete.
- Rapid deployment and demonstration of new turbine types. Moreover, early demonstration of new technology options is key so as to build the confidence amongst developers/owners, and hence increase potential volumes available to new entrants.
- Availability of financing solutions that allow for non-EU technology – such as Chinese-sourced, low cost project funding.
- Supply chain must find track record in EU jurisdiction as evidence of performance with levels of robustness (bankability).
- Need to optimise answer to logistical questions for Low Cost entrants.
- No more project gaps for supply chain stability and encourage early development of projects to give healthy pipeline.
- Learning from existing projects shared between developers and turbines manufacturers and across peers.

Evidence

Evidence of the current state of the global wind turbine market is presented in section 2.9. This section presents contemporary evidence that turbine prices do fall in response to changes in the supply/demand balance.

Overall oversupply in global turbine markets is already driving cost competition and margin reduction amongst turbine manufacturers. In some commoditised markets, costs have fallen by 20%.

Based on the stated intentions of incumbent OEMs described in section 2.6 together with a number of potential new entrants, industry expectation of a healthy balance of secure demand and competition appears to be achievable.

Evidence from the wind turbine market is currently driven by a highly cyclical pattern of demand, resulting in different competitive effects to those that are anticipated in the supply chain efficiency story. Recent research from the US onshore wind turbine market reports the effect of an increased number of suppliers on capacity and prices as demand for turbines grew rapidly.

— Section 2 illustrates the rapid growth in wind power capacity in the US up to 2010. This drew investment into the industry, with the number of manufacturers increasing from 5 in 2003 to 13 in 2008.

— Whilst an increase in supply would normally be expected to increase competition, in the US, demand continued to outstrip supply and turbine prices ($/MW) increased from $800/KW to $1,500/KW by 2008. This price inflation coincided with a US building boom and high prices for key raw materials such as steel and copper.

— Prices stabilised in 2008 and up to January 2011 had fallen on average by 20%.

— These trends illustrate how a combination of greater supplier diversity and a supply: demand imbalance have favoured the developer since 2009. This pattern can also be seen in the analysis of Siemens margins in section 2.8 from 2008 to 2011. The reduction in profit, from 12.5% to -5.1%, is not expected to be repeated over the full period of the story.

This evidence does however support the view of the industry that OEMs will respond to competitive forces in their pricing strategy.

Recently announced strategies by the established offshore wind turbine manufacturers in response to tough trading conditions have ranged from industrialising the manufacturing and assembly process (Siemens) to maximising the extent of in-region assembly (Vestas). A common strategy adopted by the majority of OEMs is the outsourcing of production to low-cost locations.

Over 60% of the costs of turbine components are focused on three main elements, blades (22%), towers (25%) and gearboxes (13%). Other components such as the generator and rotor bearings are critical in terms of performance but have much less impact on cost.

— Blades continue to be an area of technical innovation, particularly for larger turbines, and manufacture is not typically out-sourced specifically to low cost locations. There is a strong strategic logistics case to locate manufacture close to markets, which will encourage the retention of manufacture within Northern Europe. Blade manufacture has relatively high barriers to entry, and some potential supply constraint on key materials such as carbon composite can be foreseen over the duration of the story due to the large number of units required.

— Tower fabrication is highly outsourced into a fragmented market. Vestas outsource 70 to 80% of their tower production and announced the closure of a European tower manufacturing plant in February 2012[57]. There is a high potential for competition but costs are also exposed to commodity price uncertainty, which is excluded from the scope of this study. With significant potential for standardisation, tower manufacture is likely to be subject to healthy competition. Currently tower fabrication outsourcing has been focused on the onshore markets, with arrangements including:

  o Dongkuk S&C - supply of turbine towers to Bard/Enercon, Siemens and Vestas

  o CS Wind – supply of turbine towers to Siemens and Vestas

  o Titan Wind Energy - supply of turbine towers to Vestas.

  Vestas announced

— Gearbox manufacture is highly outsourced into a specialised, partially consolidated market, with suppliers including Winergy, Hansen and Moventas. Whilst much specialist casting is undertaken in low cost locations there is a premium related to specialist content. Barriers to entry are high. Technical innovation away from geared turbines to direct drive technologies may reduce the aggregate demand for gearboxes over the duration of the story, although introduction of

[57] Recharge News, Vestas boosts tower orders from China's Titan Wind Energy, February 15 2012

larger turbines will create new barriers to entry.

Research by Woodlawn Associates[58] indicates that a high proportion of the most active OEMs including Vestas, Siemens, Gamesa, Mitsubishi and Enercon have retained a relatively high level of production of key components in-house. As these manufacturers act to reduce their cost base and fixed overhead, the ability to move to an outsource model in line with the supply chain efficiency story creates a good opportunity to drive savings. Where there is a higher rate of technical innovation, production is likely to remain in-house for some of these OEMs.

Manufacturers that outsource a high proportion of content include Nordex and Goldwind. Examples of insourcing, as an alternative approach driven by quality control, customer service and product cycle considerations include Suzlon and Vestas, which produces generators and bedplates in China as well as Europe.

Whilst competition is expected to take place between OEMs, there are certain areas of the 2nd tier where constraints on the availability of key raw materials will have an inflationary impact which will potentially cancel out some of the aggregate savings offered by tier 2 suppliers. The price of steel was a major variable during the period 2006 to 2010 on the basis of global demand for raw materials and increased demand for specialist steel in European markets.

Some areas of product development may result in growing demand for scarce materials which may result in reduced competition. The two main areas of innovation, carbon fibre turbine blades and permanent magnets for direct drive transmissions are focused on increasing turbine efficiency and reliability and hence will make a significant contribution to reducing LCOE. Potential sources of scarcity include:

— Carbon fibre. As the turbine blade supply chain moves from fibre-reinforced composites to carbon fibre, total demand is forecast to reach 60,000 tonnes by 2017, two times global; carbon fibre production. [59]

— Rare earths. Permanent magnets require large quantities of the rare earth mineral Neodymium – up to a maximum of 265kg per MW according to recent research published by the Crown Estate. [60] Total global output is around 125,000 tonnes per annum. The peak period for demand for Neodymium before new sources come on stream is forecast to be 2012 to 2014/5 – prior to the rapid growth in turbines described in the four stories.

Vertical Cooperation	
2011 Situation	Typically Round 1 and Round 2 projects in the UK have been developed using a project by project approach with involvement from the supply chain limited to when the project reaches procurement stage. Some examples exist of more vertical collaboration: RWE's formal JV with Siemens on Gwynt Y Mor, SSE's offshore wind alliance which includes Siemens, call-off supply arrangements in place for Gamesa with Scottish Power and Repower and RWE and initial bidding consortia established for €10bn French offshore wind programme.
2020 Situation	Vertical collaboration necessary and seen as the norm.
2020 % Cost Reduction	-5% 2011- From 20111 Baseline (£1,024k/MW)

[58] Woodlawn Associates, ibid, Sept 2009

[59] Natural Power, Overcoming Challenges for the Offshore Wind Industry and Learning from the Oil and Gas Industry, February 2011.

[60] CleanTechCom, Use of rare earth metals in offshore wind farms, The Crown Estate, 2012.

Justification

Industry agreed that there is significant potential for savings under this lever relating to, for example:

- Better management of or complete 'designing out' of interfaces. This can also be achieved by creating more opportunities for standardisation of designs and consequent reduction in bespoke elements, i.e. interface with support structure.
- Sharing with the supply chain industry best practices that limit the impact of OEM specific elements.
- Sharing information and people between developers and turbine OEMs, OEMs and other elements of the wind farm and across the OEMs' supply chain. Greater collaboration between turbine suppliers and customers is already being sought for the larger onshore framework agreements, with develop/owner groups pooling operational data with manufacturers to optimise turbine designs, and seconding technical personnel to the manufacturing group.
- Informal or formal collaboration through alliancing. This is a proven method and many energy integrated companies now operating in offshore wind utilise this well.

The savings put forward by industry (7-8%) were challenged in workshop discussions and a more conservative position put forward to reflect the fact that some of the savings will be due to technical change, and thus covered by the technology work stream.

Timeline

It is believed that this saving could develop linearly over the period involved, as similar behaviours have already been seen with other client manufacturer groups where new technology is involved (BP/FPL and Clipper in US).

Pre-requisites

- Willingness to share operational data between operators and manufacturers.
- Turbine manufacturers being open to the notion of standardisation of certain design elements.

Evidence

A number of alliance structures involving OEMs are in place in European Offshore Wind, including the SSE offshore wind alliance, and the bidding consortia led by GDF Suez, EDF Energies Nouvelles and Iberdrola for phase 1 of France's offshore wind development.

A developer has reported a preference for long term alliance relationships as opposed to frameworks, but no cost reduction contribution was identified.

OEM BARD has pioneered a fully vertically integrated delivery model which includes control of fabrication yards, installation and O&M vessels. This approach has not seen widespread adoption but could potentially provide useful benchmark data in time.

Other turbine specific examples of vertical integration include collocation with support structure manufacturers (e.g. Bremerhaven, where two turbine manufacturers, 1 blade manufacturer and 1 foundation fabricator are collocated).

Many of the benefits secured by CRINE and OGITF relate to changes in specification, greater standardisation and rationalisation of design codes, which are partially enabled by vertical collaboration. With one dominant OEM currently operating in UK coastal waters, lack of standardisation has the potential to become a more significant issue associated with OEMs as the market diversifies, particularly if developers demand bespoke turbine products or different performance standards. The benefits of this standardisation are potentially realised through horizontal cooperation and are described in the next section. (Details of CRINE and OGITF initiatives are set out in detail in Appendix B, Oil and Gas Case Study).

Other examples of potential savings that could potentially be achieved through early engagement with OEMs include the following:

- A proposal by Siemens, for the standardisation of wind farm field capacity. Under this scenario, by developing fields in standard blocks of turbines with a common capacity – e.g. 50 x 5MW turbines, other aspects of the installation, such as substation design and installation can be standardised. This would require early engagement with the developer prior to the approvals process.

— Adoption of integrated turbine, support structure, installation methods which maximise on-shore activities.

Asset Growth and Economies of Scale	
2011 Situation	Current 3.6-4MW turbines, some 6MW turbines already operational. 41 manufacturers have announced plans to develop 51 turbine models. There is a need to test prototypes for larger turbines, which will delay market entry. No manufacturing facilities in the UK but plans announced by Siemens and Vestas. Their production could start in 2015 if FID is taken in 2012 although both manufacturers have declared that 2GW/yr deployment rate will be necessary for them to take that decision. Current capacity can deliver 300 <5MW turbines and 100 to 200 >5MW turbines per year.
2020 Situation	There will be UK manufacturing capability driven by 2GW/yr deployment rate with 450 to 550 turbines in 2019 and 2020.
2020 % Cost Reduction	-3% - From 2011 Baseline (£1,024k/MW)

Justification:

Industry agreed that the potential for savings under this lever relate to the following:

— Up to 2% cost savings from optimisation of existing processes as volumes increase due to manufacturing economies, increased utilisation of production facilities and procurement volume. The latter refers to cost reductions given as larger orders for materials/equipment/services are bought, which can range between 5 to 10%. It was perceived that further savings would be limited as this is a mature industry where significant levels of standardisation are already in place. It was also agreed that it would be necessary for the industry to coalesce around a general turbine sizing to allow the supply chain to catch up and consolidate savings.

— Investment in new capacity and in particular locating new manufacturing facilities in the UK would also result in about 1% cost savings. This represents savings in mainly logistics and transport (as these account for 1-2% of turbine manufacturing costs). A number of turbine manufacturers have published their commitment to the UK market and confirmed their willingness to build factories in the UK if there is more clarity over future volumes.

Timeline

Assuming consents begin to come through (more quickly) from 2013 onwards then the volumes being anticipated by manufacturers will start to become tangible and as such benefits will begin to accrue. Whilst some benefit will be seen for projects that reach FID in 2014, it is likely that greater benefits will be seen in 2017 and 2020.

Pre-requisites

— Consenting periods are shortened and consents come through regularly, reliably and on time to give certainty on volumes.

— Some savings are anticipated from local rationalisation of the supply chain, and so early decisions of production efforts are essential.

— Engagement of the finance community in order to understand the funding requirements of the supply chain.

Evidence

Progress curves related to volume and technical development have been observed in connection with the costs of on-shore wind turbines. Progress curves describe a factor of cost reduction that is achieved as production doubles. The progress curve recorded for large onshore wind farms in Spain between 1990 and 1998, during which time global installed capacity increased by a factor of five was 82%, implying that costs fell by 18% for each doubling of capacity. [61] The progress curve includes the effect of technical change and increased turbine size as well as economies of scale, so not all of the saving is attributable to asset growth and economies of scale. Furthermore, with current installed offshore wind capacity, now totalling 3.8GW, the future rate of saving related to volume will progressively reduce.

Evidence of volume savings that can be achieved through bulk purchase are also reported by Junginger, Faaji and Turkenburg, with an order for 1600 turbines being reported to deliver a saving of 45% on list price.[62]

Horizontal Cooperation	
2011 Situation	Horizontal collaboration limited to participation in industry forums through for trade associations such as RenewableUK and working groups organised by Government such as DECC's Cost Reduction Task Force. The scope for horizontal collaboration is limited by the extent to which developers and their supply chains are in direct competition. Certain industry wide commonality of design and best practice is happening because of lessons learnt; a certain level of informal communication occurs in the offshore wind industry. As solely informal communication, the quality of the message, and understanding transmitted is limited with industry penetration being ad-hoc.
2020 Situation	Increased horizontal collaboration with development of industry standards and sharing on some operational data across OEMs.
2020 % Cost Reduction	-2.5% - From 2011 Baseline (£1,024k/MW)

Justification

Industry concurred that there are significant savings possible through horizontal cooperation as seen in other industries. This could entail sharing knowledge, information and lessons learnt for the benefit of the industry (such as turbine operational data, design problems, supply chain issues etc.), pooling skills and resources and working towards standardising designs and codes across manufacturing peer groups.

In reality, it was felt that the industry was unlikely to maximise these benefits due to relatively insular nature of most manufacturers, and their reluctance to pool IP.

Timeline

Until new manufacturers begin to secure market share there is little incentive for leading players to participate as this challenges their market position. As such it is unlikely that the benefits from horizontal co-operation will be felt much before 2017, and then grow steadily thereafter.

Pre-requisites

- Emergence of a compelling rationale for manufacturers to pool resources and approaches, not evident as yet.
- Either competitive or client pressures force the co-operation agenda.

Evidence

There is presently little evidence of horizontal collaboration between OEMs. There may be potential where the 2nd tier supply chain is highly concentrated, such as gearboxes, where some standardisation might occur. Active OEMs in the European Offshore Wind Sector undertake a moderate level of outsourcing for elements including towers, castings and forgings, where there are limited benefits to be derived from standardisation.

New market entrants are developing a new generation of larger turbines based on alternative technologies. As a result,

[61] Junginger M, Faaji A, Turkenburg WC, Cost Reduction Prospects for Offshore Wind Farms, Wind Engineering Volume 28, Nr 1, 2004

[62] Junginger M, Faaji A, Turkenburg WC, ibid, 2004.

opportunities to standardise across all OEMs are likely to be limited. Industry argued that at the early stage of industry development, technical standardisation could reduce innovation. Greater benefits are likely to result from standardised procurement and working methods. (These processes are described in sections dealing with the installation lever (e.g. LOGIC contracts, industry standards such as Mutual Hold Harmless etc).

Where conditions for standardisation are in place, evidence from North Sea Oil and Gas Industry shows that it is a key enabler for a wider range of savings related to economies of scale and reduced costs of operation related to simplified O&M. Benefits include:

- Cost savings associated with use of standardised equipment – 25% of the cost of the equipment.
- Use of standard products offered by OEMs, rather than unintended customisation resulting from developer specific requirements.
- Improved quality assurance and quality control.

(Details of CRINE and OGITF initiatives are set out in detail in Appendix B: Oil and Gas Case Study).

Contract forms	
2011 Situation	Currently contracted using bespoke contracts (Turbine Supply Agreements) which have a lump sum price, with LDs on delay for delivery and on availability guarantees. Warranty periods tend to be 5 years with the possibility for extensions.
2020 Situation	Similar type of contracts but more standardised with increased transparency and benchmarking possible. Beginning to see some changes to contract terms (more flexible options in terms of warranties (2 years +3 years as an example), changes in definition of availability guarantees.
2020 % Cost Reduction	-1% - From 2011 Baseline (£1,024k/MW)

Justification

The savings of 1% arising from modifications to contract forms were considered to stem mainly from the increased use of framework agreements, with transparency in contracting and benchmarking needing to be properly implemented. Framework contracts improve order book visibility and as such can result in price reductions being offered. By 2020, these frameworks are likely to embody a combination of:

- Volume certainty: this sets the number of turbines that will be bought and represents a guaranteed pipeline for the OEM but may present some risk to the buyer.
- A small percentage of volume at risk - number of turbines which may or may not be bought – for the OEM this is capacity that needs to be allocated but may not be taken.
- KPIs to demonstrate competitiveness and quality of service. From 2017 the market will be more competitive, making it easier to assess the performance of suppliers under frameworks through benchmarking.

Other benefits of frameworks have already been collected under Asset Growth and Economies of Scale (see above):

- Optimisation of project timing resulting in efficiencies such as allowing for continuous work thus avoiding stop-start effects and increasing the utilisation of production lines.
- Volume related discounts.

Industry concurred that a shift in the type of Turbine Supply Agreement (TSA) for offshore wind turbines from a lump sum to a performance risk sharing/target cost mechanism was unlikely to take place in a significant manner in the period to 2020. (Although some volume risk sharing may be in place by 2020). This is because it would require increased levels of competition in the market for buyers to be able to negotiate risk sharing arrangements. As discussed below, this is unlikely to take place until

2017 and beyond.

It was also agreed that changes to contract terms (such as a move away from availability guarantees and a reduction of warranty periods from five years) would be limited as they would require the following:

- Greater understanding by the financing community and insurers about technology risk and its most appropriate allocation across the supply chain.
- Adjustment of O&M contract terms along the same line as any modifications in the TSA. As discussed below, this is also linked to increased competition in the O&M sector which is unlikely to materialise until the end of the period to 2020.

Timeline

Whilst relatively small, these savings are available to the industry from 2014 onwards and will be linear in impact, providing the pre-requisites are in place.

Pre-requisites

- Volume certainty.
- Greater use of framework agreements.
- Increasing use of alliance arrangements.

Uncontrollable risk	
2011 Situation	Weather risk is only relevant as far as delivery to hub collection point and tends to excluded from contracts. Ground conditions not relevant. Other unforeseen costs are embodied in the contract supply price.
2020 Situation	Similar to 2011 but increased ability to manage the impact of unforeseen events.
2020 % Cost Reduction	-1% - From 2011 Baseline (£1,024k/MW)

Justification

The wind turbine cost element only includes turbine supply and it excludes installation. Accordingly, the level of contingency placed on a TSA to mitigate uncontrollable risk will relate to any delays in supply due to breakdown and other unforeseen situations. Delays in supply are usually covered by liquidated damages.

Weather risk, in the event that it may impact on the delivery of the turbines to the hub collection point, tends to be excluded from the TSA and as explained in Section 3, managed by the owner/developer through a contingency and an estimation of the potential impact on outturn costs (P90).

The savings put forward represent the turbines manufacturers' ability to optimise the impact of unforeseen situations particularly. Any cost savings accrued by the owner/developer due to a better management of overspent are not included in this analysis as they are considered by PWC.

Timeline

The savings will be available from 2014.

4.5 Support structures

The supply chain market in Story 3 is predominantly characterised by mature turbines up to 6MW and with the trend towards deeper sites, the decline of monopile use and increased reliance upon jacket based construction.

As can be seen from Figure 16, by FID 2020 the capex element of support structures may experience a total reduction of 25% from the 2011 cost baseline.[63] These savings will be achieved predominantly by a combination of the following levers:

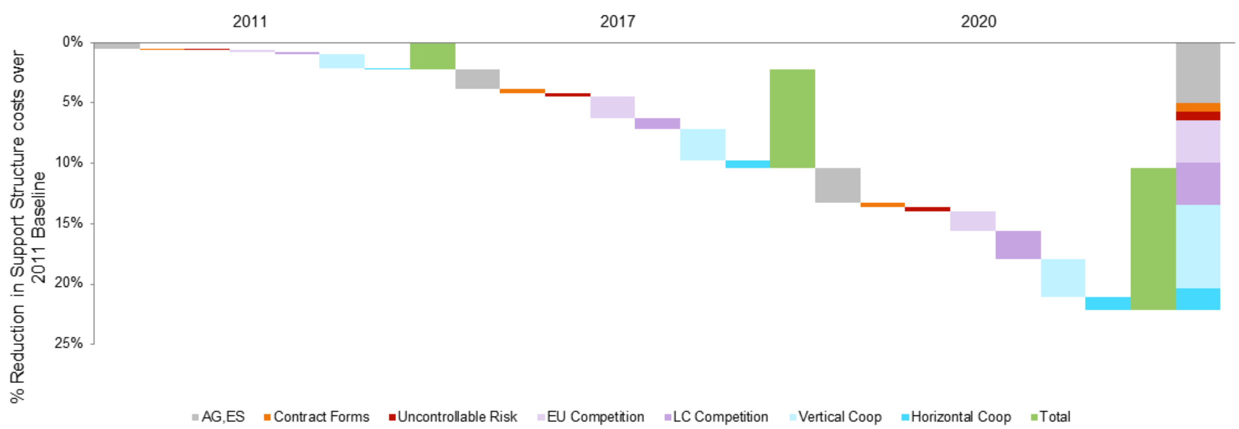
- Vertical Co-operation (7%): The interfaces between the support structures and the rest of a wind farm are logistically and technically challenging: there is the need to adequately coordinate seabed ground conditions, cable design and installation, tower design and installation, maintenance and access issues with the design and manufacture of support structures. Accordingly, the industry perceived that there is significant potential for cost reductions if these interfaces are better organised and more practised and if support structure fabricators are involved early in the project.

- Asset Growth and Economies of Scale (5%): Long term contracts allow investments in new capacity to be spread over a longer period thus resulting in cost reductions. Increased volume also results in economies of scale brought forward by, for example, rationalisation of the supply chain and standardisation of practices (learning by doing).

- Competition - European (3.5%): To deliver the capacity required under Story 3, it is expected that at least ten players will supply support structures with some transfer of resources from monopile into jacket and tripod fabrication. These entrants will help bring required capacity and investment, improved unit costs and productivity savings in a market sufficiently competitive to ensure these savings are passed to the end user. The extent of the saving is relatively low due to the high fixed costs and comparatively low-value added component in support structures compared to other elements of the offshore wind supply chain. Currently there is sufficient diversity in the monopile market, with over ten active participants, to suggest that competitive conditions will apply.

- Competition - Low Cost (3.5%): It is expected that some new entrants from the Far East will supply this market segment by FID 2020 and the use of pre-worked materials and 'flat-pack 'solutions will be more widespread.

Figure 16: Story 3: Support Structures Savings



A summary of the proposed cost reduction levels is provided below.

[63] The support structure wind farm element and corresponding 2011 cost baseline comprise foundations and towers. During industry discussions it was felt that the greatest potential for cost reduction was in the foundation element of the support structures. Accordingly, the numbers provided have been adjusted to reflect the cost saving opportunity on the correct proportion of the support structure cost element.

Table 28: Support Structures Summary

Support Structures	
Summary	
Lever	**% Cost Reduction[1] (FID 2020)**
Competition European	-3.5
Competition Low Cost	-3.5
Vertical Collaboration	-7
Asset Growth & Economies of Scale	-5
Horizontal Collaboration	-2
Contract Forms	-1
Uncontrollable Risk	-1
Compounded Total	-20[2]

Notes: (1) % Cost reduction of cost element from 2011 baseline costs of £551k/MW and net of investment costs.
(2) Calculated by multiplying all the numbers. The total is subtracted from 100% to present the total savings.

Table 29: Support Structures Supply Chain Cost Reductions by Lever

Support Structures Supply Chain Cost Reductions by Lever	
Competition from European players	
2011 Situation	Sufficient capacity in monopiles (eight suppliers). Limited and unproven supply in jackets and tripods – three or four participants, two with turbine jacket experience.
2020 Situation	Increased competition in support structures. The monopile segment already has a diverse supply chain and there are a number of potential entrants into the jacket and tripod segments. By 2020, the market under Story 3 will have at least ten active European manufacturers representing a 50% increase from current levels.
2020 % Cost Reduction	-3.5% - From 2011 Baseline (£551k/MW)

Justification

In anticipation of market size, it is expected that ten European players will be active in the jacket manufacture market. These are likely to already be undertaking similar fabrication duties for offshore and or heavy industries with an existing port location (albeit they may need to acquire better harbour access sites).

Competitive pressures are likely to result in savings through increased efficiencies, as it is felt that a certain level of competition is always present between large-scale fabrication yards mostly operating at less than full capacity.

Whilst the manufacturing of support structures is less high-tech than, for example, turbine manufacturing, the techniques used and plant required is highly specialised and the investment required to enter is high. The current market is diverse and relatively immature, which makes penetration easier, particularly for competitors from oil and gas. In most cases, purchaser loyalty is low and technical differentiation is still being developed.

New entrants may introduce alternative solutions and the development of innovations in gravity base concepts may change the conventional wisdom that jackets will prevail for use in all developments going forward.

Timeline

From 2015 (assuming volume assurance).

Pre-requisites

- Players with the balance sheet and skills required to develop jacket fabrication domestically or in the UK.
- Volume assurance.

Competition from Low Cost Jurisdictions	
2011 Situation	Sufficient capacity in monopiles (eight suppliers). One active low cost competitor partner with widely publicised quality issues.
2020 Situation	It is expected that up to two Far Eastern players will be active in this market by FID 2020.
2020 % Cost Reduction	-3.5% - From 2011 Baseline (£551k/MW)

Justification

It is expected that some new entrants from the Far East will supply this market segment by 2020. Chinese suppliers have already been used on UK projects, albeit there have been quality issues which may delay wider adoption. Many suppliers already engaged in similar work are in South Korea, Singapore and Japan, of which only the Korean yards offer unit cost reductions ex works. The following are examples of indicative relative costs ex works expected from low cost suppliers:

- Unit costs can be reduced by 30% for midsection items and by 50% euro/hr for pile stoppers and secondary steel by sourcing from low cost countries. To sustain cost reductions, there is the need for Chinese yards to enter the market. This is expected to happen with the required quality assurance achieved from FID 2017. Meanwhile Korean yard savings are available for FID 2014.
- The logistics difficulties and costs associated with low cost and Far East supply include approximately 35 day shipping duration and potential double handling costs of preformed large structures. The most likely form of low cost input is for sheet metal and other raw materials, material pre-cut, flat sheet items or particular high value items such as forged joints, machined faces. Raw material including high quality sheet (which is much lower cost in China for example) is already traded on a worldwide basis and has not been included as a potential saving. Hence pre-cut sheet and formed components with either a high cost density or good packing density are expected to be supplied from low cost suppliers, this concept is often called “Flat pack” supply or kit form.

Timeline

Saving achieved for FID 2014 using established yards in low cost supply nations and this will be sustained at the same level using new entrant largely Chinese supply from 2017.

Pre-requisites

- Assurance of volume in worldwide offshore wind industry
- A degree of standardisation or rationalisation of support structure construction methods based upon fabricated jackets.

Vertical Cooperation	
2011 Situation	Little vertical collaboration. Strabag has a JV with Northern Energy Projekt GmbH for development in the German North Sea. Bifab is a member of the SSE offshore alliance.
2020 Situation	Increased vertical collaboration with interface risks better managed as the lessons learnt from previous sites are incorporated into future project planning. The benefits of vertical collaboration understood and utilised widely.
2020 % Cost Reduction	-7% - From 2011 Baseline (£551k/MW)

Justification

Industry suggested 7% savings were likely for vertical co-operation overall. Experience from the oil and gas sector were noted where savings of 10-15% had been achieved through joint working of operator, designer, constructors and installers in alliance contractual arrangements.

Examples of potential cost savings in the supply of support structures include:

— Improving the design interface especially between cable array and support structure -an integrated design and design process was cited as being ideal, rather than multi-agency. Improvements to design would also result in requiring less time for welding angle joints on site.

— Bringing parties together earlier as a supply chain: By organising early team meetings and detailed procurement planning for jackets reduces the potential for over-ordering steel. In comparison, short bids mean an overspend on steel and overstated time to cover supplier risk because the design process has not been completed sufficiently. Earlier supply chain formulation will also assist in optimising bore holes.

— Seconding individuals or design teams into other cooperating organisations with one company acting as a central co-ordinators of the programme.

— By supply chain acquisition activities, this is thought likely to occur to a limited extent (dependant of level of assured volume apparent to the industry in Europe) but experience in oil and gas suggests this will not be the predominant vehicle for change.

Timeline

From 2014.

Pre-requisites

— Developers' ability to bring parties to the table early.

— Continued consensus move towards jacket construction techniques.

Asset growth and economies of scale	
2011 Situation	Characterised by bespoke solutions, significant fabrication challenges, lack of standardisation and high investment. Multiple players in monopile with sufficient capacity to deliver 3GW/yr. Emerging market in jacket and tripod, with capacity to deliver 0.5 to 1GW/yr.
2020 Situation	At least ten players supplying 750-800 support structures in Europe and around 300 jackets in the UK.
2020 % Cost Reduction	-5% - From 2011 Baseline (£551k/MW)

Justification

There are significant savings in support structure costs which may be achieved by a combination of the following:

— Steel supply chain capacity is based on project numbers of foundations, and towers, the total weight of steel that is likely to be required during peak production will be in the ragne of 500,000 to 750,000 tonners per annum. Current levels of global steel production exceed 100 million tonnes and in Europe exceed 14 million tonnes. The steel plate required for large scale jacket and monopile fabrication is a specialist product, but is also an area where European steel fabricators are investing in order to utilise foundry capacity. As a result, the steel supply chain is not likely to be a constraint on the support structure supply chain, although price levels will be subject to commodity price and energy price fluctuations.

— Investment in new capacity. Currently circa 300 to 400 monopile and 100 to 150 jacket/tripod foundations are made per year, many using bespoke pile design, for those using welded steel jacket construction – tooling is more ad-hoc and mixture of mono pile and jacket. 17GW of projects by 2020 and 2GW/year deployment rate, provide more certainty of return for new and established undertakings for yard investment. The unit cost for jackets for example, would reduce through investment in raw sheet handling, rolling, automated welding and bespoke unit lifting and handling facilities.

- Locating new manufacturing facilities in the UK would also result in about 1% cost savings. This represents savings in mainly logistics and transport (as these account for 1-2% of support structure manufacturing costs) and would apply for both gravity bases and jackets. These logistics savings come from comparing fabrication yards in the UK versus the rest of Europe as similar material and labour costs will apply.
- Longer term contracts with more certainty over pipeline allow more efficient serial production. This would also allow advance bulk purchasing of materials (steel, concrete), or even a long term partnering with potential subcontractors. It is also possible to reduce costs through maintaining continuity of workforce schedules, for example by working cyclically it is possible to increase productivity.
- Standardisation of the industry and practices: this will allow increased productivity of assets and labour. A foundation manufacturer suggested during the workshops that development of a standardised base solution would deliver immediate savings related to design and engineering, together with progressive year on year improvements related to productivity.
- Even though a single universal design of support structure is unlikely to emerge partly due to the need to meet site specific characteristics, the industry is driving towards modular designs and 'preferred' sizes. This leads to medium term efficiencies and opportunity for production automation. Preferred sizing is a concept employed in the manufacturing and construction industries where the potentially large range of consumer needs for a given item drives supply chain response with a compromise range of sizes to allow the consumer to get some of the benefits from economies of scale in production e.g. mobile lifting crane sizes, bolt sizes, steam turbine set sizes etc. Similar designs allow for a benchmark precedent to be set and repeated works allow for cost control measure.

Timeline

Assuming orders are placed for support structures, then savings could be realised from FID 2015 and then linearly to FID 2020 (assuming two years to build a new production line).

Pre-requisites

- Players with sufficient financial strength to make the required level of investment to meet the foreseen UK needs.
- Long term contracts.
- Engagement of the finance community in order to understand the funding requirements of the supply chain.

Horizontal Cooperation	
2011 Situation	The scope is limited by the extent to which developers and their supply chains are in direct competition. This has led to strict confidentiality policies and broad interpretations of what IP is and a keen intention to guard it. Certain industry wide commonality of design and best practice is happening because of lessons learnt; a certain level of informal communication occurs in the offshore wind industry. As solely informal communication, the quality of the message, and understanding transmitted is limited with industry penetration being ad-hoc.
2020 Situation	Increased horizontal collaboration but on items perceived to have low IP sensitivity.
2020 % Cost Reduction	-2% - From 2011 Baseline (£551k/MW)

Justification

The industry believes that there is scope for savings through collaboration towards common outcomes and sharing of information, skill, best practice, design, labour, resources, yard facilities etc. As the market becomes larger there may be more incentive to cooperate amongst peers particularly in areas that repeatedly seem to be highlighted as key to pressing need for value or to expedite the programme. The areas of mutual interest would themselves be limited and supply chain participants would want the scope and objectives strictly defined. These were highlighted as :

- Jacket tube diameters/design/ preferred sizes.

— Tower heights.

— Foundation types and design.

— Decision interface with cable array.

For example, difference in tower height between UK and European practice for current 3.5MW turbines was highlighted as a case for examination; 89m towers used in the UK when 100m is used elsewhere.

The industry did believe horizontal cooperation would occur in relation to:

— Common training facilities possibly supported by industry subscriptions and regional development assistance.

— Common working groups and standards for base items of low IP sensitivity possibly supported by industry subscriptions.

— Common working groups and standards.

Timeline

The impact of these savings could be felt from FID 2014 and then linearly increasing to FID 2020.

Pre-requisites

— Continuing cross industry intervention by industry bodies, government to highlight and define need then seed the initiatives while managing IP constraints.

— Assurance of volumes to make cooperation worthwhile from future benefits (believed to be not sufficiently in place at this time).

Contract Forms	
2011 Situation	Contracted on a lump sum fixed price basis with LDs on delay for delivery. Support structure supply contacts cover delivery to a hub collection point. In practice the transfer of risk has often been imperfect due to the contractual reliance upon the developers' base data for geotechnical bed conditions and the contractors' dependence upon the developers' performance. Resulting in valid claims payable above and beyond the lump sum price. The most frequent claims rising from liabilities for bed ground conditions, the foundations, the support structure and installation, array cable installation interface.
2020 Situation	Learning from earlier contracts and hence being more practised. More targeted use of lump sum contracts (where there is little uncontrollable risk) and a general move to performance related contracts based on outcomes rather than work packages using NEC3 suite of contracts.
2020 % Cost Reduction	-1% From 2011 Baseline (£551k/MW)

Justification

The savings accrued by this lever reflect changes in contract forms and contract terms. Other savings which can accompany changes in contracts (such as a move to alliancing, reducing interface risk by using smarter integrated vertical tier work procurement packages and volume savings) are reflected under other levers (Vertical Cooperation and Asset growth and Economies of Scale).

Industry agreed that changes in contract forms in he supply of support structures would deliver some limited savings:

— Using performance related contracts based on outcomes (such as delivery timing) rather than work package would reduce costs as they would limit supplier's contingencies to deal with potential inaccuracies of bed conditions and their impact on design and manufacture.

— Negotiated, cost plus or other low margin low risk transfer terms and conditions would also reduce outturn contract cost by reducing contractor risk allowances and the costs paid for extra costs. This would entail having similar low overheads applied to the cost of these extra works, and also subjecting extra works to compulsory market tests (for example obtaining three bids for the extra works).

— A reassessment of contract terms in particular the extent and quantum of performance bonds, liquidated damages and other sureties that are demanded from the supply chain.

Industry proposed that potential cost savings of 3-4% could be achieved by using performance models for contracting. This value has been toned down to account for the fact that support structures cover foundations and towers. The latter are not perceived to have the same issues as foundations.

Timeline

Cost reduction through changes in contracting will start to be seen from FID 2014 with greater impact from FID 2017 as some FID 2014 projects are already under contractual discussion.

Pre-requisites

— Greater understanding by the financing community and insurers about risk and its most appropriate allocation across the supply chain.

— Assurance of volume to create the environment where lessons learnt are valuable for a large future pipeline – these conditions exist with the pipeline as currently envisaged.

Uncontrollable risk	
2011 Situation	Weather risk is only relevant as far as delivery to hub collection point and tends to be excluded from contracts. Ground conditions excluded from supply contracts. Other unforeseen costs are embodied in the contract supply price. As explained under Contract Forms, this risk transfer has been imperfect due to the contractual reliance upon the developers' base data for geotechnical bed conditions and the contractors' dependence upon the developers' performance.
2020 Situation	The impact of uncontrollable risk mitigated by the use of performance related contacts.
2020 % Cost Reduction	-1% From 2011 Baseline (£551k/MW)

Justification

The support structure cost element excludes installation. Accordingly, the level of contingency to mitigate uncontrollable risk will relate to any delays in supply due to breakdown and other unforeseen situations. Delays in supply are usually covered by liquidated damages.

The savings put forward represent the manufacturers' ability to optimise the impact of unforeseen situations not already covered by the Contract Form lever. Any cost savings accrued by the owner/developer due to a better management of overspent are not included in this analysis as they are considered by PWC.

Timeline

— The savings will be available from 2014.

4.6 Planned and Unplanned O&M

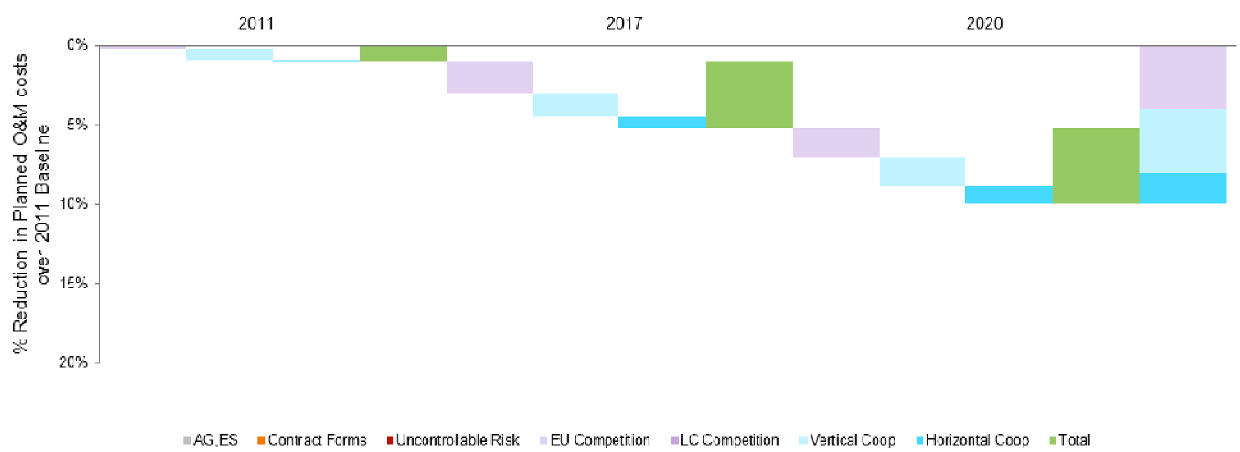
It was apparent to the industry that a significant decrease in O&M costs as a component of LCOE may be achieved going forward partly due just to the up-scaling of turbines as bigger machines will be more optimised with regard to dimensioning criteria, implying an expectation of lower lifetime O&M requirements than the older, smaller machines. [64] Also, technical innovation is likely to result in cost reductions and avoidance of unplanned maintenance by for example the use of advanced

[64] Historic evidence from the onshore market does not support the view that larger turbines experience reduced failure rates. Xanthus Energy, Offshore Wind Power for Future, 2012

conditioning monitoring and diagnostics and components with improved failure rates. These factors have been factored into technology savings covered by the technology work stream report.

Large savings were also anticipated from the supply chain (up to 30%) but it was perceived that during the study period (up to FID 2020), O&M supply chain cost reductions would not be fully realised due to the immaturity of the market, the limited number of operational offshore wind turbines out of warranty and the need to gain operational experience. Accordingly, up to 2020 it was envisaged that the costs of planned O&M would have the potential to drop by 10% (see Figure 17), whilst no supply chain cost savings were foreseen from unplanned maintenance due to its dependence on OEMs' strategies during the study period.

Figure 17: Story 3: Planned O&M



The suggested Planned O&M reductions over the 2011 cost baseline of £164/MW/yr, are mainly driven by the following levers (see Table 30).

— Competition (4% by 2020, 10% by 2030): O&M is an immature market with scope for efficiency improvements brought about by new players with more developed skills. It was suggested that it is likely that independent O&M providers will begin to participate in this market as has been seen in the onshore marketplace. However, barriers to entry are far higher in terms of capital requirements. Furthermore, OEMs are maintaining control of the O&M marketplace by tying their availability and performance guarantees to an OEM delivered maintenance regime. The industry agreed that over time, the provision of O&M services will change significantly from today with OEMs looking for longer warranty periods where they can bring savings. Unplanned maintenance is likely to remain with OEMs for longer until sufficient knowledge is gathered on the operation of new turbines.

— Vertical cooperation (4% by 2020, 10% by 2030): As with installation there is significant scope for cost savings as a result of involving O&M providers early in projects, increasing visibility around maintenance plans and longer term commitments allowing investment decisions to be made and supply chain factors to be organised.

— Horizontal cooperation (2% by 2020, 6% by 2030): The industry believes that there is significant scope for savings through information and asset sharing. In the oil and gas industry savings of around 38% (costs per barrel of oil) were achieved through the CRINE and OGITF initiatives, which combined oil and gas industry collaboration with introduction of benchmarking, commitment to training, streamlining regulations and promoting innovation rather than maintaining compliance. In the offshore wind industry timeshare and zone collaboration can realise cost savings should the finance and insurance markets permit. These will be seen as cumulative offshore wind capacity increases over time.

— Asset Growth and Economies of Scale (0% by 2020, 2% by 2030): It was agreed through industry engagement that savings from asset growth and economies of scale are unlikely during the study period due to the need for increased O&M capacity in an immature market. Post 2020, savings begin to come through.

— Contracting (0% by 2020, 2% by 2030): The industry could not outline whether contracts will play a role in reducing O&M costs within the 2020 timeframe but agreed that limited savings may be accrued post 2020.

Table 30: O&M Summary

O&M	
Summary	
Lever	**% Cost Reduction[1] (FID 2020)**
Competition European	-4 (-10 by 2030)
Competition Low Cost	0
Vertical Collaboration	-4 (-10 by 2030)
Asset Growth & Economies of Scale	0 (-2 by 2030)
Horizontal Collaboration	-2 (-6 by 2030)
Contract Forms	-0 (-2 by 2030)
Uncontrollable Risk	0 (-1 by 2030)
Compounded Total	-10[2]

Notes: (1) % Cost reduction of cost element from 2011 baseline costs of £164k/MW/yr and net of investment costs
(2) Calculated by multiplying all the numbers. The total is subtracted from 100% to present the total savings

Detail on each of the cost reduction levels is provided below.

Table 31: Planned O&M Supply Chain Cost Reductions by Lever

O&M Supply Chain Cost Reductions by Lever	
Competition from European Players	
2011 Situation	Market linked to OEMs. No stand-alone suppliers or dedicated vessels.
2020 Situation	The O&M market is likely to remain uncompetitive by 2020 due to the small pool of wind turbines out of warranty (based on a 5 year warranty period, around 1,500 turbines (in the UK), and another 1,000 in Europe) will be out of warranty by 2020). Nevertheless, post 2020, this market will start to grow, creating opportunities to open up the market to competitors. As turbine manufacturers offload their warranty liabilities, a significant market for independent O&M provision will develop with large oil and gas maintenance contractors entering the market. They may provide services as part of a broader offshore portfolio of workload. Owner/operators may also take over O&M from OEMs faster via their internal resourcing or outsourcing to industry specialists. OEMs will still be key players as they will start to offer their O&M skills to the wider offshore market. For example Vestas now offer maintenance of non Vestas turbines to its customers[65] . All these options can bring savings to LCOE on the back of a longer term approach.
2020 % Cost Reduction	4% 10% by 2030 From 2011 Baseline (£164k/MW/yr)

Justification

The industry identified that significant savings could be achieved as demonstrated in the onshore wind market where the owner taking over O&M faster has seen cost reductions of up to 25%. Nevertheless, the industry contended that there is an issue about when these savings may be realised particularly owing to warranty periods lasting at least 5 years and the volume/margins for new entrants under Story 3 (17 GW operational by 2020). The common thread being that the cost saving will not be fully realised within the study period. It was noted that their will, however, be quicker savings on larger wind turbines (this is addressed under the technology stream).

[65] Vestas Interim Financial Report November 2011

Timeline

Competition into O&M will start in from 2015-2017 (earliest at the end of 2015). Impact seen after this period.

Pre-requisites

- Information sharing on O&M.
- Shorter warranty periods.
- Availability of skilled labour (see section below).

Competition from Low Cost Jurisdictions	
2011 Situation	Linked to OEMs with no current low cost competition entrant.
2020 Situation	Japan and Korea are already priming themselves in this area looking to provide a whole lifetime service. China is a potential entrant too, despite current uncertainty around their capability.
2020 % Cost Reduction	0% (From 2011 Baseline £164k/MW/yr)

Justification

Parties insisted upon the importance of O&M being performed and scepticism remains around these low cost entrants, so the proposed cost savings were focussed on European entrants.

Vertical Cooperation	
2011 Situation	Currently delivered as part of the maintenance agreement. Little vertical collaboration.
2020 Situation	The extent of vertical collaboration is linked to the development of the O&M market. By 2020 only a small proportion of projects will have reached the end of their warranty periods. When improvements do begin to happen, cost savings are likely to be in step changes, as the various rounds of development reach the end of their warranty periods together and lessons are learned.
2020 % Cost Reduction	-4% -10% by 2030 (From 2011 Baseline £164k/MW/yr)

Justification

The industry's view is that vertical collaboration can afford savings of up to 10% in the costs of O&M over the 2011 baseline (higher savings are possible but they need owner/developers to offer long term contracts and horizontal cooperation). However, these savings will not be achievable within the FID 2020 timescale as only a small proportion of projects will have reached the end of their warranty periods.

Savings may be achieved by a combination of the following:

- Increasing the length of the O&M packages by for example establishing long term relationships would provide the opportunity to establish contracts across more than one project. It is cheaper and more efficient to deliver planned O&M services for a range of projects than individual components. For example, when visiting one turbine on a specific service, it would be possible to check other turbines/different parts of the project(s). This would reduce the need for repeat trips (a trip to 40km sites takes about 2 hours).Technical innovations such as real-time monitoring and the use of robotics to undertake routine service checks would minimise the number of people offshore and the number of offshore trips. (Technology innovation driven savings have been captured by the technology stream and thus are not reflected in the savings proposed in this study).

- Involving O&M players early (ideally during planning) could return significant savings (claimed to be as high as 30% as in the case of installation) through the identification and avoidance of risks and problems. For example, timely recognition that certain parts will need more frequent maintenance can result in them being designed lighter so they can be loaded onto small vessels facilitating O&M. Early consideration of O&M can also result with a better optimised

O&M strategy, including allowing for unplanned maintenance to be moved to planned activities if issues are identified at an early stage. Moreover, early interfacing can open up plans by utilities so that industry can commit and tool up.

- Savings can be obtained with greater collaboration across the supply chain - developers could use the same O&M contractors across multiple projects, and maintenance could be delivered by 'O&M clubs' for various sites at once. The industry could adopt existing cost-saving and HSE enhancing oil and gas practice such as the VANTAGE personnel-tracking system (see below).

- Ports could also be shared across the portfolio. Port viability increases utilisation rates increase. The offshore wind industry tends to look for dedicated facilities, but this approach results in high land requirements, low utilisation and high costs. Dedicated facilities can results in a utilization of as low as 5%. Sharing facilities can increase utilisation to 50% – 60%.

Timeline

The blended 4% reduction will start from 2017 linearly until 2020. Savings due to early involvement will not be seen until FID 2017 as projects reaching FID in 2014 are undergoing planning now.

Pre-requisites

- Owner/developer ability to encourage early involvement.

- Early visibility around data and performance of existing sites.

Evidence

In the absence of an independent O&M industry associated with offshore wind, the following observations can be drawn about the potential opportunities for savings from the approach to O&M developed in the Oil and Gas industry:

- O&M is a key area of innovation in Integrated Operations (IO), focused on the more effective integration of operator/contractor activities. A key area of activity for Oil and Gas IO is related to condition monitoring and condition-based O&M, aimed at reducing the cost and risk of routine inspection and maintenance activity.

- Wider adoption of integrated services contracting driven by operator procurement practice, (see installations above) facilitating the effective utilisation of O&M vessels etc.

- Industry wide sharing of lessons learned from live assets.

Asset Growth and Economies of Scale	
2011 Situation	No independent capacity in the market at present, bespoke solutions, linked to OEMs. Opportunities for a volume-backed post-warranty O&M market are not likely to emerge in the study period. Current OEM technology and R&D investment is aimed at achieving differentiation through improved reliability, reducing O&M requirements.
2020 Situation	Capacity required by 2020: With 1,500 installed around the UK and a further 5,400 planned to 2030 under the Supply Chain Efficiency Story, the value of O&M services for offshore wind turbines, which have a 20 year design life is both significant and long-lasting.
2020 % Cost Reduction	0% -2% by 2030 from 2011 Baseline (£164k/MW/yr)

Justification

It was agreed through industry engagement that savings from asset growth and economies of scale are unlikely during the study period. The current and foreseen future demand for O&M vessels may not reduce the rates these vessels command unless there is a major increase in these types of assets. Utilising specialist vessels from the oil and gas offshore industry may be an option but can be very costly if available supply is constrained. Day rates for highly capable semi-submersible lifting vessel from the oil and gas industry are around ten times more than for a jack-up vessel. The capacity of some oil and gas plant exceeds the capacity needs of the offshore wind, so dedicated vessels will be a better option. Although overall vessel supply is expected to improve, the limited supply of suitable vessels for maintenance activities on short term day rates is likely to keep costs high for the foreseeable future.[66]

Post 2020, Savings begin to come through by a combination of the following:

- Investment in long lead items such as vessels if these investments can be spread over a longer period. Longer O&M contracts (i.e. 5-10 years) could actually prove 25% cheaper for O&M with the caveat that long term deals involve risk around exchange rates, fuel costs etc.
- To allow cost savings to be made across O&M in general, investment is required across various aspects of the supply chain. The industry needs to ensure it is investing in the right technologies which will allow cheaper O&M delivery. For example, a leading cable manufacturer has developed a new range of products that are fully interchangeable which leads to lower O&M costs. Equally, it was suggested that developing and improving the efficiency and O&M effectiveness of 6/7MW turbines would noticeably decrease maintenance and service costs, which is significant since 90% of the opex is driven by performance of wind turbines.
- Standardisation of the industry including maintenance plans: this will allow increase productivity of assets and labour. For example, using vessels for more than one project can provide significant savings, making maintenance 30% faster on subsequent projects i.e. utilising the same boat, team, harbour, etc. To date, vessels are chartered for one project at a time; by looking long term and extending fids to more than one project, savings in excess of 25% are available.

Timeline

Main savings will be seen post FID 2020. This is because unlocking the benefits from asset growth and economies of scale necessitates warranty period to expire, investment in long lead items (such as maintenance vessels) and critical mass in the market (entrance of new players).

Pre-Requisites

- Long term contracts.
- Increased number of players in the market.
- Expiration of warranty periods.
- Engagement of the finance community in order to understand the funding requirements of the supply chain.

Evidence

The following enablers have been identified from insight from the Oil and Gas industry:

- Personnel access. Rapid and safe transfer of maintenance personnel to offshore wind turbines is an area of concern and has featured in the second phase of the Offshore Wind Accelerator. There will be a major requirement to increase vessel availability. Based on existing projects, one personnel transfer vessel is required for approximately every 25 turbines.
- For major repairs/replacement works, operators are expected to charter vessels as required to perform any major repair/overhaul work. The industry view is that one vessel capable of lifting a turbine or rotor will be required to service each 600 turbines. Based on the Supply Chain Efficiency Story, this suggests that an additional installation vessel will be required every 18 months from 2015 to meet O&M needs cost effectively. Given design and fabrication lead-in times, commissioning will need to occur well before FID 2020 in order to ensure that O&M requirements do not constrain installation capacity.
- Accommodation. Capacity will also be required in offshore accommodation and helicopter fleets to enable effective working in farms further out to sea.
- Management resource. Recruitment and training of key supervisory and health and safety professionals has the potential to be a constraint – particularly if the wind industry is competing with Oil and Gas– projects have been

[66] www.offshorewindenergy.org

delayed in North Sea waters due to a lack of key experienced staff.

Horizontal Cooperation	
2011 Situation	Horizontal collaboration limited to participation in industry forums through for trade associations such as RenewableUK . The scope for horizontal collaboration is limited by the extent to which developers and their supply chains are in direct competition. Certain industry wide commonality of design and best practice is happening because of lessons learnt; a certain level of informal communication occurs in the offshore wind industry. As solely informal communication, the quality of the message, and understanding transmitted is limited with industry penetration being ad-hoc.
2020 Situation	Horizontal cooperation beginning to develop as market matures but with greater potential for saving post 2020.
2020 % Cost Reduction	-2% -6% by 2030 - From 2011 Baseline (£164k/MW/yr)

Justification

The industry believes that horizontal collaboration can afford savings significant savings but these are not likely to be fully achievable within the period to 2020 due to the immaturity of the industry.

Savings are likely to stem from driving towards common outcomes and sharing of information, labour, vessels ('time share' to reduce vessel downtime) and port facilities both within the offshore wind industry and across the oil and gas industry. For example, if some regulations are harmonized to make it simpler for companies to operate in both offshore oil and gas and offshore wind, there is potential to both reduce costs (bearing in mind that oil and gas safety standards have to be higher than required in offshore wind and as a result, more expensive). This is particularly true for the manpower and equipment required to build, maintain, operate and decommission offshore assets. In these areas the two industries are likely to compete for resources, but would benefit from a collaborative approach to establishing basic training for offshore staff, common standards acceptable to both industries, standards in procurement which would apply equally to both supply chains.

Standardising turbine design would also lead to efficiencies in O&M as spare parts for several offshore wind farms could be in one location, and skills required to maintain turbines could be more generic than they currently are, which would open up the maintenance market to more competition, and hence lower prices.

Sharing of knowledge associated with O&M requirements will benefit the industry – particularly new operator entities. As an example, Vestas miscalculated the amount of harbour space needed to service Horns Rev offshore wind farm due to lack of previous experience. The result was delay, logistical issues and increased cost. This learning has been applied to wind farm logistics on subsequent schemes.

Also, there will be a requirement for larger logistics bases, which store replacement. A leading maintenance company identified that these facilities will be most efficient where they serve more than one offshore wind farm. Likewise, as well as the requirements for storage, there will be an opportunity to develop robust logistics chains to ensure components can be delivered quickly to where they are needed this bring further efficiencies to the O&M function (both planned and unplanned).

Timeline

The impact of these savings could be felt from FID 2017 and then linearly to FID 2037.

Pre-requisites

— Availability of training courses that are applicable across a number of O&M solutions and technologies.

— Owner/operator's ability to encourage cooperation.

— Liability clarity on sharing and impacts of events.

Evidence

In the absence of an independent O&M industry associated with offshore oil and gas, the following observations can be drawn from the approach to O&M developed in the Oil and Gas industry:

— Health and safety considerations are paramount in the marine environment. To ensure cost effective universal safety standards, the O&G industry has developed industry-wide Minimum Safety Training Standards, approved by OPITO. Training records are held in the Vantage database, enabling managers to confirm cost effectively those operatives have the appropriate training. The Offshore Wind industry is developing its own standards, led by RenewablesUK.

— The development of specific standards for the wind industry may reduce the extent of operative cross over between O&G and wind.

Factors enabling working within Wind and O&G would include:

— Common training and competence.

— Common safe systems of working and permits to work.

— Common design and installation standards.

— Shared supply chains. Shared facilities include vessels and helicopters. In the O&G industry, these are procured using standard pre-qualification documents and contracts.

The Vantage Personnel on Board system is an example of an industry wide initiative which has facilitated the efficient development of an independent O&M function for the benefit of industry participants. Vantage tracks over a million personnel movements per year to and from over 420 locations. Created under the LOGIC initiative it has achieved cross-industry collaboration and funding, and delivering a large-scale internet enabled system, is currently used by over 35 leading oil companies and their supply chains. By enabling independent suppliers to operate a single industry wide system, Vantage has increased operative safety and has also reduced barriers to entry for independent suppliers.

Contract forms	
2011 Situation	Within the warranty period, O&M is part of the Turbine Supply Agreement. Currently the main option in the market is to extend warranties or obtain a LTSA from Turbine OEMs and BOP suppliers. Currently, operational projects are under warranty by OEMs who are keen to protect their R&D and capture market share. Hence, they are not that willing to modify contract terms.
2020 Situation	The O&M market in 2020 lacks the diversity and competitiveness required to drive significant changes in contractual forms.
2020 % Cost Reduction	0% -1 to -2% by 2030 - From 2011 Baseline (£164k/MW/yr)

Justification

— The industry could not outline whether contracts will play a role in reducing O&M costs within the 2020 timeframe. The new entrants would consider incentive driven contracts and a modification of contract terms once they understand the assets and the performance of them. The International Marine Contractors Association (IMCA) produce a standard contract for its offshore marine and underwater engineering companies, based on a standardised contract developed for the oil and gas industry under the LOGIC initiative.[67]

The industry agreed that changes in contract forms could return 2% savings post 2020 due to:

— Moving to incentivised contracts based on MWh generated rather than availability guarantees (per turbine and farm) would allow O&M providers to optimise the service driven by outputs rather than the contractual need to keep wind turbine running 96% of the time. Vestas have introduced output based guarantees as part of their maintenance offer.

— Relaxing warranty periods as in the oil and gas industry where warranties tend to be two years maximum. This modification of contract terms would need to be accepted by the financing community and insurers.

— Framework agreements with appropriate KPIs can also provide savings as they allow the O&M provider assurance of

[67] www.logic-oil.com/contracts.cfm

volume.

Timeline:

It is unlikely that the proposed savings will materialise until post FID 2020 due to the need to have less reliance on OEMs.

Pre-requisites

— Bigger O&M market.

— New entrants.

— Greater understanding by the financing community and insurers about risk and its most appropriate allocation across the supply chain.

— Move towards standardised contracts.

Uncontrollable risk	
2011 Situation	Weather and ground conditions tend to be excluded. Other unforeseen costs are embodied in the contract supply price.
2020 Situation	No significant change from 2011.
2020 % Cost Reduction	0% -1% (by 2030) - From 2011 Baseline (£164k/MW/yr)

Justification

— It was agreed that a small net saving (up to 1%) can be accrued on the O&M post 2020 by optimising downtime. The savings may be significantly larger but they have been tempered down as some are covered under horizontal collaboration and also to reflect the need for long term agreements.

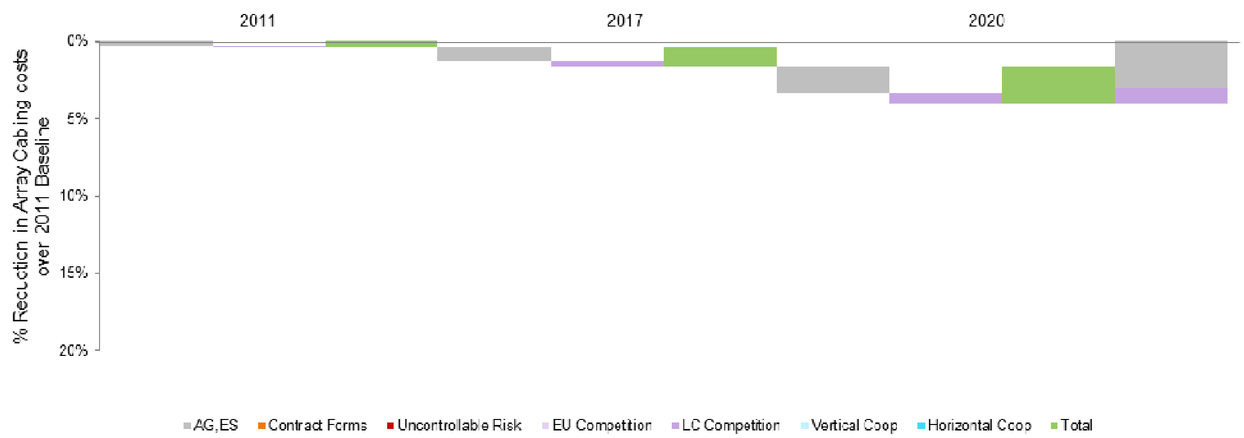
Pre-requisites

— Long term contracts.

— Maintenance organisations in the market with the right skills and balance sheet to manage uncontrollable risk.

4.7 Array cables

Figure 18: Story 3: Array Cables – Savings



The graph above indicates that scope for the supply chain to reduce costs in the array cable element of an offshore wind farm is not likely to be significant by FID 2020 – up to 3% over the 2011 cost baseline of £80k/MW. This is because the array cable market is mature with significant levels of competition and cable is a commodity product. Also, the cost contribution of array cables to the total capex and opex of an offshore wind farm is less than 1% therefore the impact of any cost reduction in this element is minimal.

Modest cost savings will be achieved through the following:

— Asset growth and economies of scale (3%): These cost savings result from procuring larger volumes in standard lengths. This also includes cost reductions stemming from offshore wind dedicated manufacturing capability.

— Competition from low cost jurisdictions (1%): To meet the capacity required for 2020 under Story 3, either existing players increase capacity or new players enter the market. This cost reduction assumes that the market includes one low cost supplier putting a blended cost reduction pressure on the market of 1%.

Towards the end of the study period, Story 3 envisages the introduction of high voltage array cabling (see the description of Story 3 in Table 32). The supply chain for this type of cable is immature and niche and therefore no supply chain cost savings are envisaged as a result of their initial introduction. Technology related savings are reflected in the technology work stream report.

5 Cost Reduction Pathways: Stories 1-4

5.1 Introduction

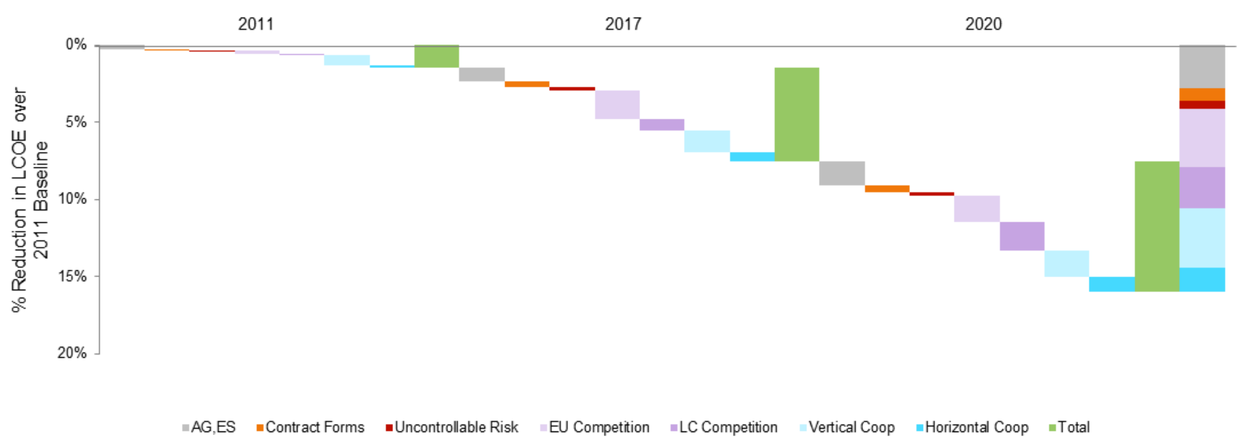
This section presents how the supply chain may effect LCOE reductions under all the Study's stories from today to 2020. As in Section 4, the savings proposed depict a base case scenario, with no fluctuations in currency and commodity prices. They are accrued by changes in supply chain behaviour and are over and above any cost reductions associated with the technology and finance streams.

The characteristics of the Study's Stories are summarised in Table 32 and the evolution of LCOE under each story discussed in turn below.

5.2 Story 3: Supply Chain Efficiency

By 2020, the supply chain cost reductions analysed in Section 4 for installation, support structures, wind turbines, array cables and O&M result in an overall reduction in LCOE of 15% compared to 2011 (see Figure 19).

Figure 19: Story 3: Supply Chain Efficiency: Cost reductions by Lever



This fall in LCOE is driven mainly by an increase in competitive pressures, better vertical cooperation across the supply chain and maximising asset growth and economies of scale.

Story 3 depicts a market of 17 GW of operational capacity by 2020 (36GW in Europe) with deployment rates of 2GW/yr (average). Driven by assurance of volume, the UK becomes a key market in offshore wind attracting new entrants and investment with about 550 turbines and support structures being deployed into the UK market per year during the peak years of the scenario, 2019 to 2020. This volume is met by incumbents expanding existing facilities and by new entrants. The current uncompetitive segments in the industry become competitive with up to six wind turbine OEMs supplying the market (UK and and rest of EU), at least 10 manufacturers of large jackets and enough installers to offer buyer's choice. There is also an increasing presence, albeit still limited, of players coming from the Far East offering lower cost solutions. O&M remains strongly linked to OEMs as the number of operational turbines out of warranty is still low thus limiting the opportunity to develop competition and reduce costs significantly.

Table 32: Story Descriptions

Story	Slow Progression	Technology Acceleration	Supply Chain Efficiency	Rapid Progression
Summary	• Incremental evolution from today's technology • Continuous improvement, focussed on reliability improvement • Small technology steps – not big leaps • Gradual transition from 4MW to 6MW turbines over the period	• Progressive shift towards larger turbines to reduce OPEX/MW and increase yield • High levels of innovation in support structures and installation methods • Diversity of solutions	• Incremental evolution from today's technology • Continuous improvement, focussed on reliability improvement and improved production processes • Small technology steps – not big leaps • Gradual transition from 4MW to 6MW turbines over the period • Accelerated learning by doing • Increased investment in new production technology	• Multiple technological solutions • Transition towards larger turbines • Track record for 4/6MW turbines achieved early on due to scale • Accelerated learning by doing • High levels of innovation in support structures and installation methods
Change by 2014	• Entry of larger offshore specific turbines at 6MW • Next generation of purpose-built installation vessels available • Improvements to access and evolution of vessels and maintenance strategies that only partially account for increased harshness of conditions	• Partial use of floating LIDAR to improve understanding of site conditions • Significant uptake of 1st generation 6MW turbines • Second generation support structures • Next generation of purpose-built installation vessels available Improvements in access methods and evolution of vessels and maintenance strategies that account for increased harshness of conditions • Advanced lifetime cost modelling focuses additional investment on problem areas reducing long term maintenance requirements	• Entry of larger offshore specific turbines at 6MW • Next generation of purpose-built installation vessels available • Improvements to access and evolution of vessels and maintenance strategies that only partially account for increased harshness of conditions	• Partial use of floating LIDAR to improve understanding of site conditions • Significant uptake of 1st generation 6MW turbines • Second generation structures • Next generation of vessels available • Improvements in access methods and evolution of vessels and maintenance strategies that account for increased harshness of conditions • Advanced lifetime cost modelling focuses additional investment on problem areas reducing long term maintenance requirements
Change by 2017	• Reasonable optimisation of site layout based on multi-variable modelling, with limited verification of	• Full optimisation of site layout based on multi-variable modelling, with limited verification of models	• Reasonable optimisation of site layout based on multi-variable modelling, with limited verification of	• Full optimisation of site layout based on multi-variable modelling, with limited verification of models

Story	Slow Progression	Technology Acceleration	Supply Chain Efficiency	Rapid Progression
	models • Partial use of floating LIDAR to improve understanding of site conditions • Increasing penetration of 6MW 1st generation turbines • Some novel jacket solutions and designs driven by ease of installation • Improved models of support structure/soil modelling • Entry of 60kV AC inter-array cables • Occasional use of advanced installation methods • Advanced lifetime cost modelling focuses additional investment on problem areas reducing long term maintenance requirements	• Routine use of floating LIDAR • Entry of 60kV AC array cables and some DC array solutions • 6MW 1st generation and 2nd generation turbines dominate • Some novel jacket solutions and designs driven by ease of installation • Tower designed with foundation • Improved modelling of support structure/soil interface • Occasional use of advanced installation methods including float out and sink solutions • Partial use of purpose built maintenance vessels that can remain permanently stationed at far shore sites with the capacity to undertake large component replacement	models • Partial use of floating LIDAR to improve understanding of site conditions • Uptake of 6MW 1st generation and 2nd generation turbines • Some novel jacket solutions and designs driven by ease of installation • Improved models of support structure/soil modelling • Entry of 60kV AC array cables • Occasional use of advanced installation methods • Partial use of purpose built maintenance vessels that can remain permanently stationed at far shore sites with the capacity to undertake large component replacement • Advanced lifetime cost modelling focuses additional investment on problem areas reducing long term maintenance requirements	• Routine use of floating LIDAR • Entry of 60kV AC inter-array cables and some DC array solutions • 6MW 1st generation and 2nd generation turbines dominate • Tower designed with foundation • Improved modelling of support structure/soil interface • Occasional use of advanced installation methods including float out and sink solutions • Partial use of purpose built maintenance vessels that can remain permanently stationed at far shore sites with the capacity to undertake large component replacement
Change by 2020	• Matured wind farm design optimisation methods • Routine use of floating LIDAR • Entry of 2nd generation 6MW turbines; 1st generation 6MW turbines dominate; limited use of 4MW turbines. • Increasing penetration of 60kV AC inter-array cables • Routine use of advanced installation methods, including	• 6MW turbines dominate, but with limited uptake of 10MW turbines • Advanced array cable solutions • Routine use of advanced installation methods, including float-out-and-sink solutions • Routine use of purpose built maintenance vessels that can remain permanently stationed at far shore sites with the capacity to undertake large component	• Matured wind farm design optimisation methods • Routine use of floating LIDAR • 6MW turbines dominate • Increasing penetration of 60kV AC array cables, also with some DC array solutions • Occasional use of advanced installation methods, including float-out-and-sink solutions for selected sites	• 6MW turbines dominate, but with limited uptake of 10MW turbines • Advanced array cable solutions • Routine use of advanced installation methods, including float-out-and-sink solutions • Routine use of purpose built maintenance vessels that can remain permanently stationed at far shore sites with the capacity to undertake large component

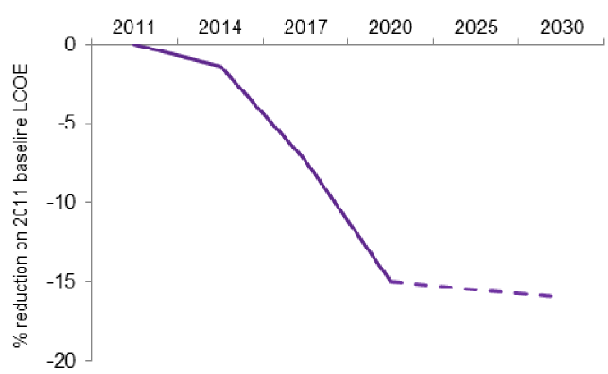
Story	Slow Progression	Technology Acceleration	Supply Chain Efficiency	Rapid Progression
	float-out-and-sink solutions for selected sites • Routine maintenance of far shore projects is undertaken using adapted hotel vessels supported by conventional installation vessels for large component replacement.	replacement	• Routine use of purpose built maintenance vessels that can remain permanently stationed at far shore sites with the capacity to undertake large component replacement	replacement

In order to deliver the required volume and encouraged by market size, industry deepens vertical collaboration from today's levels. In Story 3, players maximise early involvement and undertake it formally through alliancing and frameworks or informally and even at risk with the understanding that it will improve their ability to win work. Increased vertical collaboration reduces costs as it limits the amount of reworking necessary; it optimises processes and allows the supply chain to plan more adequately. There is also active management of interfaces both across wind farm elements and within supply chains. This brings significant benefits as it reduces contract contingencies and cost overruns.

In Story 3 technology change is gradual with improvements taking place around the 4 and 6MW turbines (see Table 32). This allows the supply chain to mature, maximise economies of scale and standardise practises. Moreover, the UK develops indigenous manufacturing capability in both turbines and foundations thus reducing logistics and transport costs as well as bringing other wider economic benefits.

There is a general shift to performance rather than cost driven contracting with an increase use of incentivation and risk sharing. This means that risk is either allocated to entities best able to manage it or shared amongst parties and allows a better understanding of outturn costs. If contingencies to manage unforeseen risks are embodied in the contract price, buyers are not able to ascertain whether the outturn costs imply an upside or a cost overrun. This has implications for developer's risk. Over the study period, in Story 3 developers are able to reduce their estimation of outturn costs and the contingencies they apply to projects as they gain better understanding of risk through transparent pricing and risk sharing with their supply chain. The savings accrued by this are reflected in the finance work stream report by PWC.

Figure 20: Story 3 Timeline



In terms of cost saving potential across the different sites, the results of the analysis and industry consultation suggest that from a supply chain perspective there is no difference even though there are some technology implications. For example, Site B will entail a change to jacket foundations, Site C requires vessels with deep sea capability, which according to Section 2, will be available from 2014 thus not representing a supply chain constraint. The longer distance from shore for Site D means that transfer stations at sea will be required to minimise cycle time. As per Story 3 (see Table 32), these become available by 2017.

The timeline for cost reduction under Story 3 (see Figure 20) shows a gradual cost decline in the first half of the period due to the impact of early collaboration to changes in contractual arrangements with a ramp up from 2016-2017 due to the increased impact of competition.

5.3 Story 1: Slow Progression

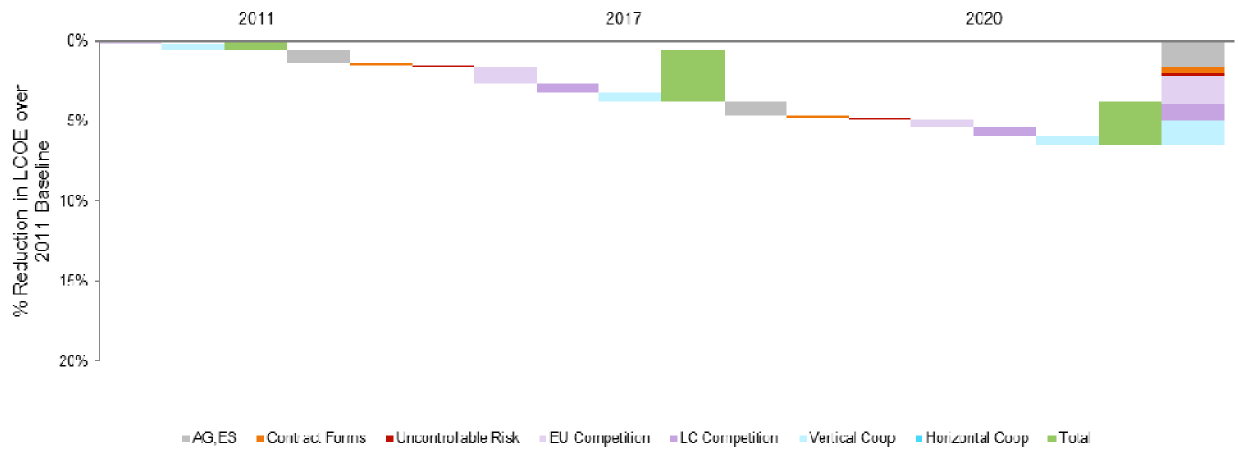
As a result of industry engagement it was agreed that by FID 2020 under Story 1: Slow Progression, the supply chain could effect a reduction in LCOE of 6% from the 2011 baseline. These savings would mainly stem from economies of scale which allow learning by doing; some competitive pressures and vertical collaboration (see Figure 21).

Under Story 1, technology does not change radically throughout the period thus allowing some economies of scale and standardisation to take place affording cost savings over today. This is particularly the case in support structures and installation where the largest potential for reducing bespoke solutions and introducing standard solutions lays.

A UK market with 12GW of operational projects by 2020 would entail significant levels of investment in asset growth and capacity over today's levels. It is anticipated that this increase in volume will be met by existing players along the supply chain augmenting capacity in an incremental manner and by a limited number of new entrants from both European and Far Eastern regions. We envisage that there will be a maximum of three to four turbines suppliers active in the UK market (two to three European and one of the most advanced Far Eastern players). There would also be five or more foundation manufacturers and an increase in the number of installers currently in the market. There may be an incentive for the bigger players to enter the market by transferring skills from the oil and gas sector, although this effect may be limited by competition within the offshore wind market and demand from the oil and gas sector for decommissioning. With regards to array cable, it is unlikely that the size of the European market would be sufficient to incentivise the development of dedicated manufacturing capacity. Nevertheless, increased volumes from current levels should lead to some competitive pressures along the supply chain, increasing buyer's choice.

In order to achieve the volumes suggested under this story, there is the need to increase vertical collaboration from current levels. Accordingly, the emergent signs of early involvement and the current desire to improve interface management across the supply chain continue and further develop under Story 1, albeit at a lower pace than in Story 3.

Figure 21: Story 1: Slow Progression: Cost reductions by Lever

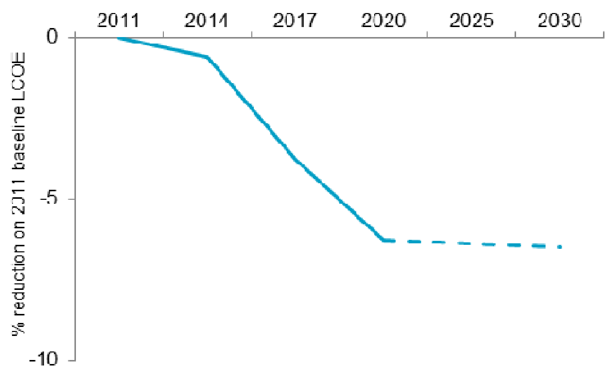


One of the challenges associated with Story is the steep decline in support structure and installation levels peak volumes in 2019 and 2020 to post-peak volumes of 250 to 300 turbines and support structures per annum from 2022 onwards. The signals sent by the Story are that the sustainable long term capacity within the UK is below 40% of the levels of the peak in 2019/20.

As a result, the scope for savings over today's costs is limited because capacity is deployed at a rate of 1GW/yr which is not sufficient to attract manufacturers to the UK. This means that savings from the localisation of the supply chain to the UK can not materialise but more importantly, the UK becomes a marginal market with manufacturing facilities being located elsewhere. Suppliers potentially focus on other more lucrative markets in Europe or further afield. Moreover, the financial markets do not deepen and the financing and insurance community still perceive the offshore wind industry as risky. This hinders investment and unlocking asset growth albeit necessary as indicated above, remains difficult.

Moreover, in Story 1, the supply chain is less keen to challenge the status quo and exploit efficiencies to the maximum; contracting forms and procurement practices do not change significantly, and there is little cooperation amongst peers. In terms of developers' risk, even though there is not a significant shift to risk sharing as per Story 3, there is learning that takes place by doing and by focusing on the same turbine classes. This increased understanding will allow developers to lower contingencies and expectations to outturn costs, albeit less significantly than per Story 3. (This is covered in the finance work stream report).

Figure 22: Story 1 Timeline



The savings accrued under Story 1 take place gradually from today as a result of learning from Round 1 and Round 2 projects and as volume increases, through some standardisation. They then rise more steeply as a result of capacity growth and competitive pressures towards the later part of the period. (See Figure 22).

Sites have the same cost saving profile as per Story 3. The key difference being that if cost reductions are limited, there may be a preference to develop easier sites with the more difficult ones being at risk of not reaching developers' FID thresholds.

5.4 Story 2: Technology Acceleration

Story 2 is characterised by rapid technology change without the accompanying supply chain maturity. Technical innovations across all the elements of the wind farm are introduced with 4, 6, 8 and 10MW turbines featuring in the market by FID 2020 as well as innovative support structures, cabling arrangements, installation methods and O&M practices (see Table 32). The market by 2020 develops to 17GW in the UK and 36GW in Europe (including UK) with a deployment rate of 2GW/year (average).

During the focus interviews and workshops, it was agreed that that Story 2 is likely to present the most challenges in terms of its potential to achieve significant cost reductions from a supply chain perspective:

— The rapid introduction of new technological solutions means that the market, albeit the same size as that developed under Story 3, remains fragmented with only a few players able to supply the different technology segments.

— Although there may be more players supplying the market (due to the diversity of technology solutions) a significant number of those will compete on the basis of product differentiation in niche markets. Competition based on projected lowest cost of energy based on different availability and O&M cost profiles of geared and direct drive turbines is an example of potential product differentiation. As a result of greater product differentiation, lowest capital cost competition in different market segments could potentially be limited.

— The supply chain cannot exploit efficiencies as technology changes rapidly. This limits the scope for economies of scale and standardisation. These represent key cost savings opportunities under Story 3, which cannot be fully realised under Story 2.

— The supply chain perceives the market as risky due to rapid technology change and investment in asset growth is more guarded as there is a concern that the supply chain will develop stranded assets if they invest in the 'wrong' technology.

— Technology differentiation and the need to protect IP for all the different technology solutions, makes cooperation across peers more challenging than in Story 3.

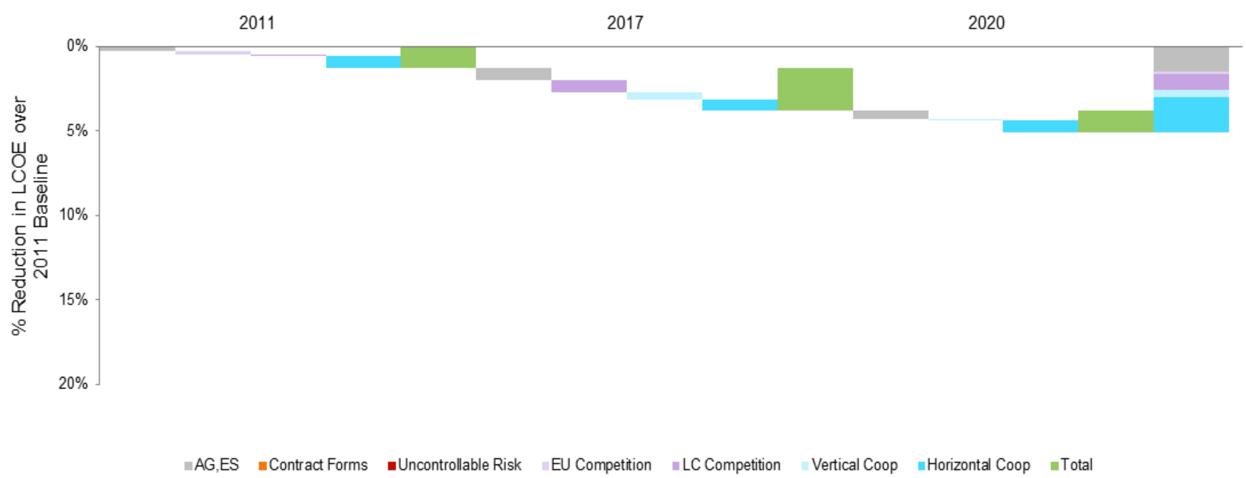
— The supply chain is likely to struggle managing risk through contractual change as packages will embody significant level of technology risk (new, less proven solutions). It also proves difficult to rationalise procurement as the differentiation across the supply chain will be greater than in Story 3.

— Rapid technology change accompanied by supply chain immaturity will lead to a slower reduction of project contingencies than in Story 3 as players need to learn and fully understand the impacts of technology change in the field. Therefore, developers are likely to keep overall project contingencies and estimation of cost outturns at the same level as Story 1. (This is covered in the finance work stream report by PWC).

— Capacity constraints are likely to emerge in turbine installation and O&M related to super-large machines (e.g. >8MW). Competition from the oil and gas sector and O&M requirements may reduce available installation capacity.

Accordingly, by 2020 the impact on LCOE under Story 2 is limited to 5% reduction over the 2011 baseline (Figure 23).

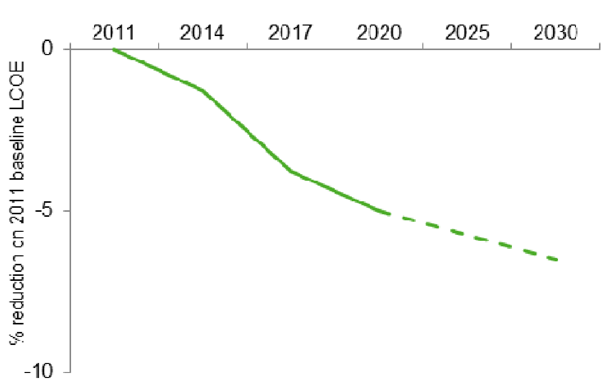
Figure 23: Story 2: Technology Acceleration: Cost reductions by Lever



The cost savings stem from:

- Technology innovation will lead to some of the component interfaces being either totally designed-out or made simpler. This will reduce interface risk and afford some efficiencies, in particular during installation.
- Some standardisation may be possible particularly in support structures (jackets) where increasing turbines size may be dealt with by changing modular designs rather than designing complete bespoke solutions.
- 2GW/year deployment rate will result in some localisation of the supply chain albeit to a lesser extent than in Story 3 as the 2GW/yr will cover a much wider range of solutions.

Figure 24: Story 2 Timeline



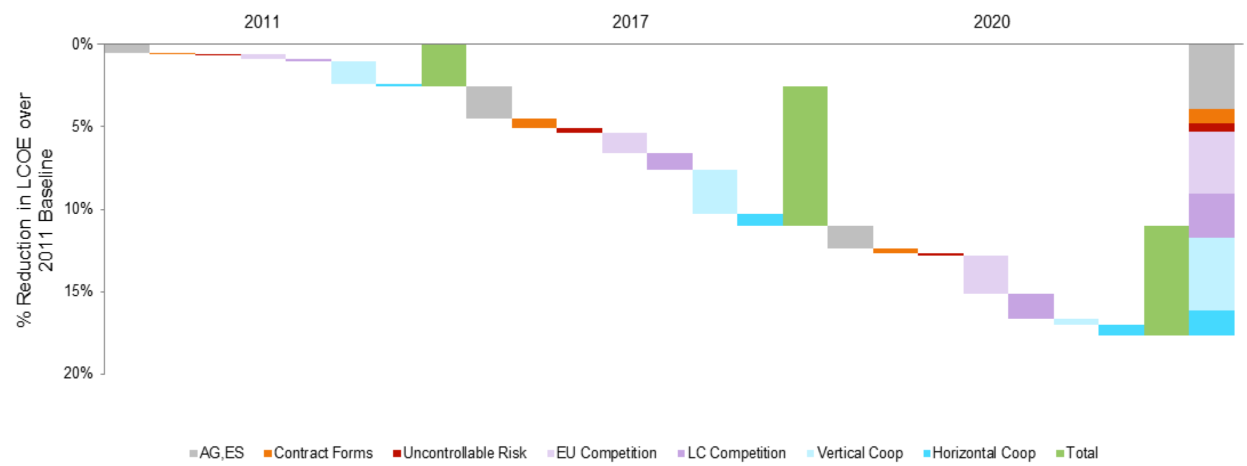
The savings accrued under Story 2 take place gradually from today (see Figure 24). Sites have the same cost saving profile as per Stories 3 and 1. In this case, difficult sites may be easier to develop aided by larger turbines thus requiring fewer trips offshore, innovative support structures, installation methods and O&M practices.

5.5 Story 4: Rapid Growth

The Rapid Growth story includes the supply chain developments achieved under Story 3 with high levels of technology evolution and the introduction of multiple technological solutions. In comparison to Story 2, the supply chain is able to gain greater maturity along the different technology segments and technology risk is reduced and better allocated. The depth of financial markets deepens and the market evolves to 23GW of operational projects by 2020 in the UK and 43GW in Europe (including UK). The deployment rate rises to 3GW/year (average).

During discussions with industry, it was decided that only a further 1% fall in LCOE over Story 3 may be achieved by FID 2020 bringing the total LCOE reduction to 16% over 2011 (see Figure 25). Savings greater than this were considered to be unrealistic as the volumes predicated under Story 4 already take the risk of overstretching the market. This could lead to a constraint on resources (including human capital) which would in turn put pressure on costs and counteract some of the advantages proposed by this story.

Figure 25: Story 4: Rapid Growth: Cost reductions by Lever



The cost saving profile of Story 4 is likely to be very similar to that in Story 3. The increased savings are likely to come from the following:

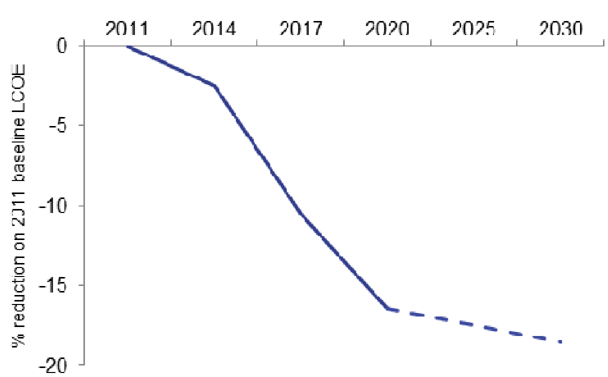
— Greater efforts made to increase UK supply chain capacity and size of manufacturing facilities.

— Larger volumes also allow greater levels of economies of scale related savings.

— To achieve the required volumes, the supply chain has to collaborate more closely. Vertical cooperation is evident through improved contracting and construction methodologies. There is also more horizontal collaboration driven by a less protective attitude towards company practices in favour of industry wide benefits.

As with Story 3, there is a general shift to incentive contracting and risk sharing. This coupled with a larger pool of projects and thus more experience in the market, allows developers to reduce overall project contingencies and estimation of cost outturns more aggressively than in Story 3. (This is covered in the finance work stream report).

Figure 26: Story 4 Timeline

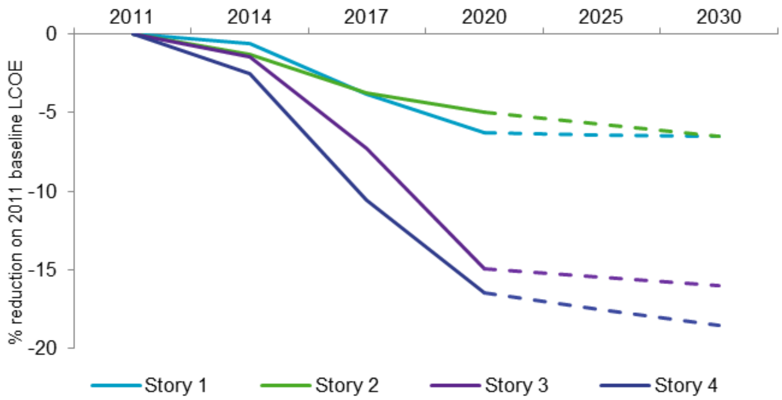


The savings accrued under Story 4 follow a similar timeline to Story 3 but more accelerated (Figure 26). Sites have the same cost saving profile as per the other stories. In this case, focus will be on developing all available sites in order to get the volume. As per Story 2, technological change will help in dealing with the more complex sites.

5.6 Cost Reduction Pathways Post 2020

The evolution of the proposed cost reduction pathways post 2020 is summarized in Figure 27.

Figure 27: Post 2020 Cost Reduction Pathways



— Story 1: Slow Progression: It is likely that the cost reductions achieved by FID 2020 will stabilize with no significant further increases. Under this story the UK offshore wind market becomes marginal within the European and global markets making it difficult to better its position.

— Story 2: Technology Acceleration: Under this story, the supply chain struggles to catch up by FID 2020 limiting the saving potential. Post 2020, as technology becomes more proven, the pace of technical change stabilises, and the market becomes more competitive, it is expected that some of the benefits seen under Story 3 will come through.

— Story 3: Supply Chain Efficiency: Post 2020 there will be a small increase in LCOE reduction due to the development of a more competitive O&M market followed by a levelling out of cost saving potential.

— Story 4: The savings under Story 4 are limited by supply chain capacity. If this develops in the period post 2020, it is possible that cost savings under Story 4 will increase.

6 Sensitivities

A wind farm utilises significant quantities of commodities during its construction and significant elements are sourced from outside the UK, principally in Europe. Consequently, both the capital and operational costs are affected by variations in commodity prices and the pound-euro exchange rates. The Crown Estate conducted a statistical analysis of the likely range in rates and prices on a P10 to P90 basis for the Pound-Euro exchange rate, plus copper, steel and concrete prices. Those ranges were used to assess the impact on the baseline capital and operational costs in 2020 under the Supply Chain Efficiency Story market conditions for a wind farm of site type B utilising 6MW turbines. The effect on capital and operational costs were used to derive an associated impact on the out turn levelised cost of energy. Those results are summarised in the table below:

Table 33: Summary on capital and operational costs impact on out turn levelised cost of energy

Rate/Price	P10 to P90 range	Capital cost range	Operational cost range	LCOE
Pound - Euro	+/- 15%	+/- 7.8%	+/- 7.1%	+/- 7.0%
Copper	+/- 65%	+/- 1.3%	+/- 7.2%	+/- 3.3%
Steel	+/- 50%	+/- 5.2%	+/- 1.2%	+/- 3.0%
Concrete	+/- 50%	+/- 0.3%	+/- 0.0%	+/- 0.2%

The LCOE is most sensitive to variations in the pound-euro exchange rates. Hence, certainty in costs can be best achieved by insulating capital construction and operational activity from fluctuations in the currency markets. The effects of commodity prices is much lower, although there is a noticeable impact of both copper and steel commodity prices, suggesting efforts to fix these prices will deliver best certainty in the overall outturn costs. As the modelling is based on jackets, concrete is not a significant contributor to the capital costs and is barely utilised during operations. Hence, even a wide fluctuation in its price has no significant impact on outturn costs.

7 Pre-requisites and Timeline

7.1 Pre-requisites

It is clear from the engagement with all groups across the value chain that great ambitions and expectations continue for the UK offshore market and the supply chain opportunities that might reasonably be anticipated. If these goals are to be realised then urgent action is required to ensure that the pre-requisites for such growth are put in place. These are summarised below.

Pre-requisite 1: Increase Market Certainty and Volume Visibility

Market certainty and volume visibility influence the asset growth and economies of scale and competition cost reduction levers. In order for the offshore wind supply chain to make the necessary investment in new capacity and for new players to enter the market, there is the need for assurance of volumes. Visibility on volume, both through the short, medium and long term is vital if the large capital investments into manufacturing plants, port facilities and vessels are to be secured. Raising the funds to undertake the required investment will necessitate a clear business case with visibility and certainty over the forward order book. It also needs to be recognised that a large "bubble" of development in the 5/6 year period from 2014 will not, alone, suffice for many of these investments, which will ideally see a continuing build programme through to 2030 to really underpin the investment case. Moreover, market opportunity as indicated by assured market volume, is likely to attract strong players with the balance sheets required to make the necessary investments. Market assurance will also help early involvement and vertical cooperation as the supply chain is more likely to be wiling to undertake work at risk (pre-appointment) in a market with numerous opportunities with the understanding that it will improve their ability to win work later.

To gain greater visibility on volumes the following are required:

— Certainty over offshore wind financial support (EMR) to 2020 and beyond.

— A smooth transition from ROCs to CfDs.

— An examination of the planning process to increase transparency, speed and certainty. Difficulties consenting fundamental onshore elements of projects frustrates and delays investment and development. These uncertainties continue to bolster a perception that significant risks remain around consenting and therefore a cautious approach to wider spending pre-consent is often seen. Also, greater transparency and certainty over the consenting regime should allow for a less risk-averse attitude to spending during the consenting phase of work to develop, delivering savings from the co-operative opportunities that should evolve, and an accelerated delivery of volume through this phase of the work.

— Certainty over treatment of offshore transmission assets.

Pre-requisite 2: Sufficient Timely Capacity in Prototype Testing Sites

In order for new entrants to be able to supply the UK offshore wind market, access to prototype sites is required in particular for wind turbines and foundations.

A study undertaken by GL Garrad Hassan suggests that in absence of further development, there will be a shortage of onshore prototype testing sites for 8-12 wind turbine units by 2015 rising to 15 by 2018. The study also indicates that there will be a shortage of offshore demonstration sites for 20-25 wind turbine units by 2015 extending to 2020.[68]

Limited testing sites will inhibit competition (and thus cost reductions) as new entrants need to prove their products in order to make them attractive to purchase.

[68] GL Garrad Hassan, 'Gap Analysis of Test and Demonstration Facilities for Offshore Wind Technology', August 2011.

Pre-requisite 3: Educate and Engage Finance and Insurance Communities

The finance and insurance communities need to understand the offshore wind industry more closely in order to facilitate the ability/willingness of the industry to modify current risk allocation practises. This is particularly the case for potential new entrants who are not yet in the sector but could be in the future – for example institutional investors, pension funds (and their advisors), and sovereign wealth funds. In some cases these players have not committed significant resource or time to the offshore wind sector, and would benefit from gaining greater understanding. As demonstrated by the Finance Stream Report, these players will play a vital role solving the finance challenges faced by the offshore wind sector.

The financing community also needs to better understand that funding opportunities in the offshore wind sector extend from Tier 0 (investment in projects) to all tiers in the supply chain.

Better informed and engaged finance and insurance communities will allow cost reductions to stem from changes in contract forms and the treatment of uncontrollable risk and vertical collaboration (through different apportioning of risk by reducing interfaces and cooperation models such as alliancing). It will also facilitate the much needed asset growth required in the industry which will then bring savings through economies of scale and standardisation.

Pre-requisite 4: De-risk Pre-consent Stage

De-risking the pre-consent stage of projects by for example aiding information sharing across the supply chain in particular relating to sea ground conditions and wind speed will facilitate collaboration. It was clear that many cable, foundation and installation contractors felt that they could add significant value to the development process if they were engaged earlier, but developers often cited budgetary pressures during the consenting phase as a major reason for delaying such discussions until post-consent when the potential value of such discussions may already have been partly lost.

Pre-requisite 5: Common Standards in Place

Developing technical, operational and contractual standards across the different elements of the supply chain will foster cooperation and reduce bespoke elements. Also, fostering industry wide forums for the discussion of lessons learnt and sharing best practise ensuring that they deliver best value.

Pre-requisite 6: Appropriate Levels of Appropriate Human Capital Available

In order for the industry to develop in a sustainable manner and achieve the proposed cost reductions, it is paramount that the necessary human capital is available in terms of both numbers and skill sets:

— Increase potential for transference of skills from other sectors, in particular Oil and Gas.

— Equalise rates for transferable skills across offshore industries (Oil and Gas and offshore wind).

— Assess training requirements.

If this does not take place, the outcome would be either that:

— Projects could be delayed through lack of human resources.

— There could be an increased risk of H&S incidents, which could have reputational implications for the sector.

— Costs could go up if there is competition from other sectors such as O&G.

The interaction between the pre-requisites ands the supply chain cost reduction levers is given in the table below.

Table 34: Pre-requisites and Supply Chain Cost Reduction Levers

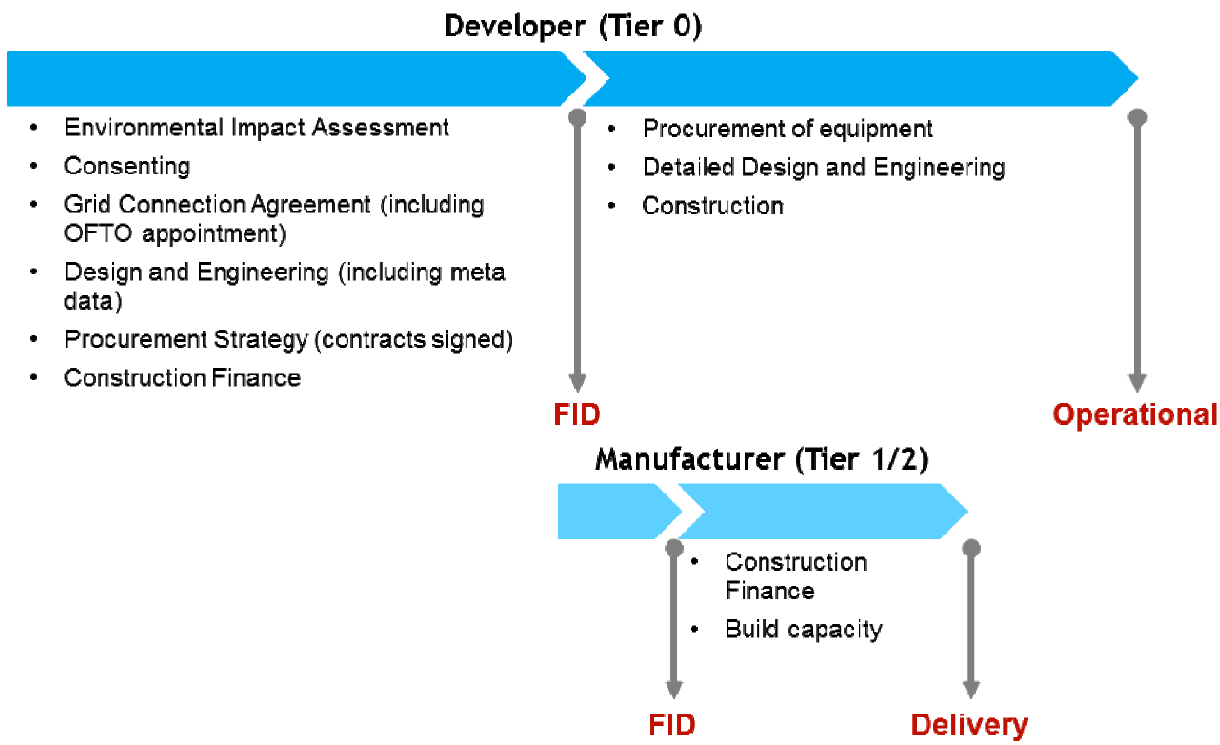
Pre-requisite	Supply Chain Cost Reduction Lever
Pre-requisite 1: Increase Market Certainty and Volume Visibility	Asset Growth and Economies of scale Competition Vertical and Horizontal Collaboration
Pre-requisite 2: Sufficient Timely capacity in Prototype Testing Sites	Competition
Pre-requisite 3: Educate and engage the Finance and Insurance Communities	Asset Growth and Economies of Scale Vertical Collaboration

Pre-requisite	Supply Chain Cost Reduction Lever
	Contract Forms Uncontrollable Risk
Pre-requisite 4: De-risk Pre-consent Stage	Vertical collaboration Horizontal Collaboraton
Pre-requisite 5: Common Standards in Place	Asset growth and Economies of Scale Vertical Collaboration Horizontal Collaboration
Pre-requisite 6: Appropriate levels of Human Capital Available	Affects all levers

7.2 Timeline

In order for the industry to achieve the cost reduction pathways outlined in this study, decisions need to be made within a determined timeframe. This timeframe will differ depending on the supply chain actor. Figure 28 depicts, in a simplified manner, the approach followed by a wind farm developer (Tier 0) and its associated supply chain (Tier 1,2) under a traditional contracting model. A significant number of activities need to be completed prior to the developer reaching FID for the project. These tasks provide progressively more detail about the project in order to gain more certainty over programme and costs. Once FID has been reached for the project, the developer places orders for equipment.

Figure 28: FID Interactions Across Supply Chain Tiers



Under this model, it is only at that time that the supply chain reacts with price offers and delivery plans (which may include building new capacity). Typically, offshore wind key equipment suppliers/manufacturers (Tier 1 and 2 of the supply chain); require visibility of orders before making large investment decisions. They are also likely to need the security of forward workload to obtain the necessary finances to expand capacity. Large wind turbine manufacturers and supply chain actors with large balance sheets are an exception in this respect. As indicated in section 2, some of these companies are part of large groups with significant financial strength. Also, they tend to be technology driven companies where a percentage of their turn-over is dedicated to R&D, D and thus invest in new products and capacity ahead of definite orders.

In the offshore wind sector where significant level of investment in new supply chain capacity is required, this model can lead to limited opportunity for cost reduction prior to project reaching FID, significant risk of price hikes due to capacity constraints and delays due to long lead times. As explained in section 4, these risks can be ameliorated and cost savings achieved, by using a cooperative approach with early supply chain involvement. This may involve for example, alliancing or the use of framework agreements that offer some volume certainty.

As discussed in the report (section 5 and summarised in Table 40), the supply chain cost saving opportunities for projects reaching FID in 2014 in Story 3 are limited; as by then the market will still be underdeveloped with uncompetitive segments prevailing (such as in turbine supply and installation) and developers paying constrained market prices. Moreover, for projects expected to reach FID in 2014, many of the activities in the pre-FID stage are either already completed or at an advanced stage of development with little scope for change and thus cost reduction. Most FID 2014 projects are likely to have completed the pre-planning work and would be looking to submit their planning application in 2012.

Table 35: Story 3 – Profile of the Impact of Supply Chain Factors on LCOE

FID	% LCOE reduction
2014	1%
2017	7%
2020	15%

Projects with FID 2014 are likely to be in the design and engineering phase with a contracting strategy either already in place or at advanced stages of development. This limits the ability to improve by early involvement of the supply chain, changing from traditional contracting forms and risk sharing approaches. FID 2014 projects are likely to use already existing supply chain capacity (such as in vessels for turbines and foundations). Decisions to expand in cable installation, port infrastructure and foundations need to be taken now for delivery in 2014/15. As demonstrated in section 2, there could be a significant ramp up in capacity reaching FID by 2014. Story 3 assumes that circa 2.5GW would reach FID in 2014. This is a massive increase on the rate at the current time (<1GW p.a.). Therefore the supply chain needs to scale up by then in order that FID 2014 projects can actually be deployed in the 2016-18 window.

The interaction between timings and pre-requisites is summarised in the table below.

Table 36: Story 3: 2014 FID Timing and Pre-requisites

Story 3: FID 2014, 1% LCOE reduction from Supply Chain factors			
Player	**Key decision**	**Timing**	**Pre-requisite**
Developer	Early involvement with installers and O&M	**2012**	**Pre-requisite 1:** Increase market certainty and volume visibility
Installation (cables)	New entrants in cable installation FID for specialised cable laying/installation vessels	**2012** **2012 such that vessels available in 2015/6**	**Pre-requisite 1:** Increase market certainty and volume visibility **Pre-requisite 5:** Common standards in place **Pre-requisite 6:** Develop appropriate human capital and ensure adequate players and transference of skills from O&G industry and other sectors
Turbine manufacturers	Logistics savings through location of manufacturing facilities in the UK - FID for UK manufacturing facilities	**2012** (manufacturing facilities available by 2014/2015)	**Pre-requisite 1:** Increase market certainty and volume visibility
Support structures	FID for capacity expansion in jackets	**2012** (jackets available in 2014)	**Pre-requisite 1:** Increase market certainty and volume visibility in order to secure finance for expansion
O&M providers	FID new specialised O&M vessels	**2014** in order for vessels to be available in 2017/18	**Pre-requisite 1:** Increase market certainty and volume visibility **Pre-requisite 6:** Develop appropriate human capital (and assure O&G skill transference)

Story 3: FID 2014, 1% LCOE reduction from Supply Chain factors			
Player	**Key decision**	**Timing**	**Pre-requisite**
			Pre-requisite 3: Educate and engage the finance and insurance communities (to allow changes in contracting strategies)
Ports	FID for development of required infrastructure for construction	**2012/3** (port available for construction in 2014/5)	**Pre-requisite 1:** Increase market certainty and volume visibility
	FID for development of required infrastructure for O&M	**2016** (port available for O&M from 2018)	**Pre-requisite 1:** Increase market certainty and volume visibility

Under Story 3, for projects reaching FID 2017, there is significant more scope for savings (up to 7% reduction of f LCOE) due to the appearance of new entrants, increased vertical cooperation, changes in contracting structures and development of economies of scale though standardisation and mass production facilities. The timing and pre-requisites required for these cost savings to be realised are summarised in the table below.

Table 37: Story 3: 2017 FID Timing and Pre-requisites

Story 3: FID 2017, 7% LCOE reduction from Supply Chain factors			
Player	**Key decision**	**Timing**	**Pre-requisite**
Developer	Early involvement with all supply chain	**2013**	**Pre-requisite 1:** Increase market certainty and volume visibility
	Clarity of scope and reduced risk allowances in solutions from contractors	**2013**	**Pre-requisite 4:** De-risk pre-consent stage
	Modification of current contracting forms and risk allocation practises	**2012** start educating finance and insurance communities **2014** change contact structures	**Pre-requisite 1:** Increase market certainty and volume visibility to incentivise change **Pre-requisite 3:** Educate and engage the finance and insurance communities (to allow changes in contracting strategies)
Installers	New entrants, increased competition including players from O&G industry	**2013** (for development of training and O&G skill transference) in order for new players to be available by 2017	**Pre-requisite 1:** Increase market certainty and volume visibility to incentivise new entrants **Pre-requisite 6:** Develop appropriate human capital (and assure O&G skill transference) **Pre-requisite 3:** Educate and engage the finance and insurance communities (to allow funding of supply chain)
	FID for the development of deep water installation vessels (including cable laying vessels)	**2014** in order for vessels to be available in 2017/18	**Pre-requisite 1:** Increase market certainty and volume visibility to raise necessary funds
Turbine manufacturer	New entrants, increased competition	**2013** access to prototype testing sites **2016** prototypes proven	**Pre-requisite 1:** Increase market certainty and volume visibility **Pre-requisite 2:** Sufficient timely capacity in prototype testing sites
Support structure manufacturer	FID for capacity expansion in jacket manufacturing	**2015** (jackets available in 2017)	**Pre-requisite 1:** Increase market certainty and volume visibility to secure funds required for expansion

Story 3: FID 2017, 7% LCOE reduction from Supply Chain factors			
Player	**Key decision**	**Timing**	**Pre-requisite**
			Pre-requisite 3: Educate and engage the finance and insurance communities (to allow funding of supply chain)
	FID for required investment for new entrants (some located in UK)	**2013** for new capacity to be available in 2015/6 (including testing)	**Pre-requisite 1:** Increase market certainty and volume visibility to incentivise new entrants **Pre-requisite 2:** Facilitate access to prototype testing sites **Pre-requisite 3:** Educate and engage the finance and insurance communities (to allow funding of supply chain)
O&M providers	New entrants, increased competition (either from O&G or other specialists providers)	**2020** in order for to be available in 2021	**Pre-requisite 1:** Increase market certainty and volume visibility **Pre-requisite 6:** Develop appropriate human capital (and assure O&G skill transference) **Pre-requisite 3:** Educate and engage the finance and insurance communities (to allow changes in contracting strategies) **Pre-requisite 5:** Common standards in place.
Ports	FID for development of required infrastructure for construction	**2015/6** (port available for construction in 2017/8)	**Pre-requisite 1:** Increase market certainty and volume visibility leading to developer (Tier 0) commitment. **Pre-requisite 3:** Educate and engage the finance and insurance communities (to allow funding of supply chain)
	FID for development of required infrastructure for O&M	**2019/20** (port available for O&M from 2021/2)	**Pre-requisite 1:** Increase market certainty and volume visibility leading to developer (Tier 0) commitment. **Pre-requisite 3:** Educate and engage the finance and insurance communities (to allow funding of supply chain)
Supply chain (general)	Reduce costs through standardisation and information sharing across peers	**2012** (it is assumed that this activity increases throughout the period)	**Pre-requisite 1:** Increase market certainty and volume visibility to incentivise cooperation **Pre-requisite 5:** Common standards in place.

Under Story 3, projects reaching FID 2020 could achieve a further 8% reduction in LCOE (compared to 2017). This stems from further competition, greater degree of cooperation, a mature supply chain which can maximise economies of scale and standardise practises with a deeper understanding and apportioning of risks. The timing and pre-requisites required for these cost savings to be realised are summarised in Table 38 below.

Table 38: Story 3: 2020 FID Timing and Pre-requisites

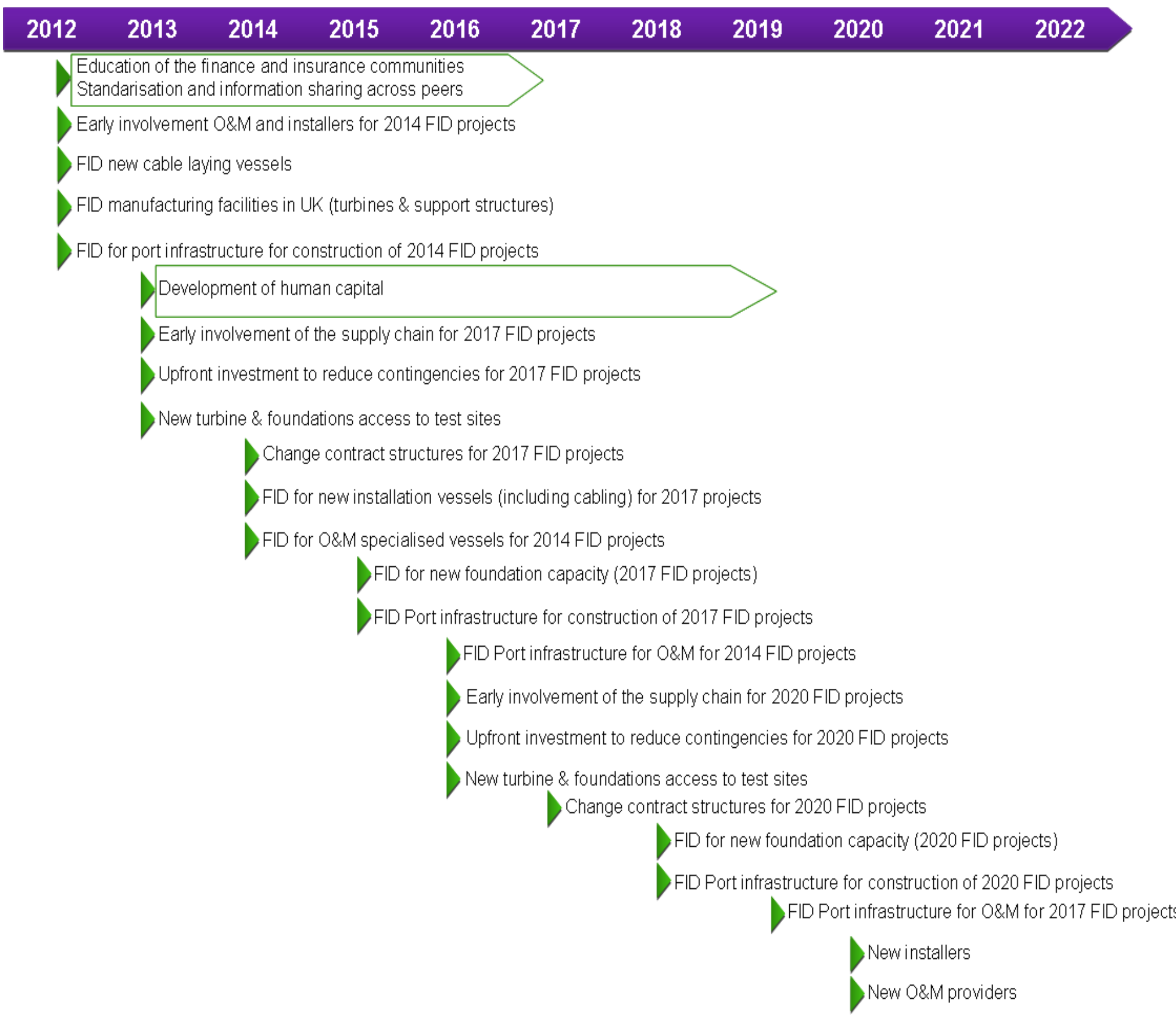
Story 3: FID 2020, 15% LCOE reduction from Supply Chain factors			
Player	**Key decision**	**Timing**	**Pre-requisite**
Developer	Early involvement with all supply chain	**2016**	**Pre-requisite 1:** Increase market certainty and volume visibility

Story 3: FID 2020, 15% LCOE reduction from Supply Chain factors			
Player	**Key decision**	**Timing**	**Pre-requisite**
	Clarity of scope and reduced risk allowances in solutions from contractors	**2016**	**Pre-requisite 4:** De-risk pre-consent stage
	Modification of current contracting forms and risk allocation practises	**2012** (it is assumed that this activity continues throughout the period) **2017** to change contact structures	**Pre-requisite 1:** Increase market certainty and volume visibility to incentivise change **Pre-requisite 3:** Educate and engage the finance and insurance communities (to allow changes in contracting strategies)
Installers	Further new entrants, increased competition including players from O&G industry	**2013** (for development of training and O&G skill transference). This activity continues throughout the period. **2020** further new players available	**Pre-requisite 1:** Increase market certainty and volume visibility to incentivise new entrants **Pre-requisite 6:** Develop appropriate human capital (and assure O&G skill transference)
Turbine manufacturer	Further new entrants, increased competition	**2016** access to prototype testing sites **2019** prototypes proven	**Pre-requisite 1:** Increase market certainty and volume visibility **Pre-requisite 2:** Sufficient timely capacity in prototype testing sites **Pre-requisite 3:** Educate and engage the finance and insurance communities (to allow funding of supply chain)
Support structure manufacturer	FID for further capacity expansion of existing facilities in foundation manufacturing	**2018** (jackets available in 2020)	**Pre-requisite 1:** Increase market certainty and volume visibility to secure funds required for expansion **Pre-requisite 3:** Educate and engage the finance and insurance communities (to allow funding of supply chain)
	FID for required investment for further new entrants (some located in UK)	**2016** for new capacity to be available in 2018/9 (including testing)	**Pre-requisite 1:** Increase market certainty and volume visibility to incentivise new entrants Pre-requisite 2: Facilitate access to prototype testing sites **Pre-requisite 3:** Educate and engage the finance and insurance communities (to allow funding of supply chain)
O&M providers	Further new specialised O&M vessels Further new entrants, increased competition (either from O&G or other specialists providers)	**2020** in order for players and vessels to be available in 2024	**Pre-requisite 1:** Increase market certainty and volume visibility **Pre-requisite 6:** Develop appropriate human capital (and assure O&G skill transference) **Pre-requite 3:** Educate and engage the finance and insurance communities (to allow changes in contracting strategies) **Pre-requisite 5:** Common standards in place.
Ports	FID for development of required infrastructure for construction	**2018/9** (port available for construction in 2020/1)	**Pre-requisite 1:** Increase market certainty and volume visibility leading to developer (Tier 0) commitment. **Pre-requisite 3**: Educate and engage the finance and insurance communities (to allow funding of supply chain)

Story 3: FID 2020, 15% LCOE reduction from Supply Chain factors			
Player	**Key decision**	**Timing**	**Pre-requisite**
	FID for development of ports for O&M	**2022** (port available for O&M in 2024)	**Pre-requisite 1:** Increase market certainty and volume visibility leading to developer (Tier 0) commitment. **Pre-requisite 3:** Educate and engage the finance and insurance communities (to allow funding of supply chain)
Supply chain (general)	Reduce costs through standardisation and information sharing across peers	**2012** (it is assumed that this activity increases throughout the period)	**Pre-requisite 1:** Increase market certainty and volume visibility to incentivise cooperation **Pre-requisite 5:** Common standards in place.

A summary of the key decisions is given in Figure 29.

Figure 29: Story 3 Cost Reduction 2012-2020 Timeline



7.3 Priority

The table below summarises and prioritises the pre-requisites (under Story 3) using the following system:

— Impact: High/Medium/Low

— Intervention required: High/Medium/Low.

Table 39: Pre-requisite priorities

Pre-requisite	Impact	Intervention required
Pre-requisite 1: Increase market certainty and volume visibility	H	H
Pre-requisite 2: Sufficient timely capacity of prototype testing sites	M	M
Pre-requisite 3: Educate and engage the finance and insurance communities	H	M
Pre-requisite 4: De-risk pre-consent stage	M	M
Pre-requisite 5: Common standards in place	M	M
Pre-requisite 6: Appropriate levels of human capital available	H	M

Overall, pre-requisites 1, 3 and 6, relating to confidence in the market, engagement of the finance community and the availability of adequate human capital, seem the most significant from a supply chain perspective and essential for the achievement of the cost reductions put forward.

7.4 Other Stories

The pre-requisites apply to all the study stories but their relative importance differs. For example, the requirement for prototype test sites (pre-requisite 2) and the need to educate and engage the finance and insurance communities (pre-requisite 3) will be more significant under Story 2 than in Story 3. This is due to the greater introduction of new technology (more testing required and higher technical risk). Pre-requisite 6: Appropriate levels of human capital available, will be more important for Story 4 where capacity volumes and deployment rates are higher than in Story 3.

The timing of decisions is also applicable, the key difference being the number of actors that need to make such decisions and whether there is room for slippage in the decision-making process. In Story 1, the fact that volumes are lower implies that fewer supply chain actors need to undertake the activities put forward in the report and thus some of the timings suggested for Story 3 may be delayed. In contrast, Story 4 requires much higher levels of activity, greater number of players being involved, higher levels of investment and a more accelerated timescale in comparison to Story 3 in order to achieve the volumes and associated cost savings.

Appendix A Methodology

The Supply Chain work stream has two clear deliverables that are well defined:

1. Supply Chain Cost Reductions Pathway Matrix:
    - Describing % cost reduction forecasts across agreed seven cost levers and seven wind farm elements
    - Core matrix describing cost reduction for ‘Supply Chain Efficiency’ and savings in 2020
    - Adjustment factors to translate the data for all 4 stories, 4 sites and 3 points in time
    - Clarity indicating how the final savings forecast are calculated and the relevant sources of data
    - Including a scatter diagram for each cell of the matrix highlighting data sources
    - Evidence which supports and adds credibility to the savings figures in the matrix
    - Consistent with and for input to the overall BVG model.
2. Supply Chain Cost Reductions Pathways Report, covering:
    - Overview of the current status of the UK offshore wind industry
    - General market conditions and expected market trends
    - Commentary on key characteristics
    - Framework/baseline for the potential cost reduction pathways to 2020
    - Pre-requisites
    - Approach for construction and population of the supply chain matrix
    - Support for the data contained in the supply chain matrix
    - Research to support critical gaps in the matrix where industry has not been able to provide a clear point of view.

Our approach to achieve these deliverables followed a structured approach consisting of seven broad steps:

1. Plan project and develop pathways
2. Test pathways and validate
3. Industry engagement (Focus Interviews)
4. Research
5. Supply chain cost reduction pathways model and matrix development
6. Industry endorsement (Workshops)
7. Reporting

For each of these areas we have a detailed methodology designed to drive robustness and the avoidance of critical gaps. This is detailed below.

Plan Project and Develop Pathways

Objectives

To fully understand the objectives of The Crown Estate's Project Team, agree details of scope and assumptions underpinning work identify all available relevant information and agree project management procedures. Additionally, to develop a straw model of pathways, set up the model and risk profile as well as agree the engagement process with industry.

Key engagement:

— Detailed start-up meetings with the Project and Integration Teams.

— Engagement with organisations as required to obtain available background info relating to relevant available studies.

— Cross-work stream engagement (Finance) and engagement with The Crown Estate to discuss:

  - Cost reductions
  - Pathways
  - Model development
  - Risk profile development
  - Industry engagement process

Analysis:

— Extraction and rationalisation of available information from relevant studies and previous work within our own organisations.

— Development of straw model pathways, model and risk profile.

Output:

— Confirmed project work programme, including cross-work stream alignment for and integration activities and timetable with the finance stream and The Crown Estate.

— Straw model pathways developed.

— Main cost reduction opportunities identified.

— Modelling input understood and agreed.

— Risk profile defined.

— Industry engagement process defined.

— Plan for project communications and endorsement agreed.

— Team ready to begin initial industry engagement.

Test pathways and validate

Objectives

To test the straw model pathways with The Crown Estate and the wider project team.

Key engagement

Having developed the outline cost reduction pathways, confirm their relevance to the sector and consistency with the broader cost reduction pathways model by:

— Working closely with the technology stream to ensure the supply chain pathways are consistent and complimentary

— Ensure consistency and understand interdependencies with the finance work stream

— Validate the cost reduction levers and the wind farm elements to which they will be applied with The Crown Estate

— Review with finance work stream and The Crown Estate risk profiling and input to the overall model.

Additionally:

— Begin to organise the logistics for the 1 to 1 meetings and future workshops.

Analysis:

— Extraction and rationalisation of available information from relevant studies and previous work within our own organisations.

— Development of straw model pathways, model and risk profile.

Output:

— Straw model pathways tested at high level.

— Programme of meetings organised (being organised).

— Initial model costs entered and reviewed.

— Understanding of risk profiling.

Industry Engagement (Focus Interviews)

Objectives:

To gather and validate detailed qualitative and quantitative input from key stakeholders and use this to help shape workshops and input to the supply chain model.

Key engagement:

— 19 Focus Interviews with key industry organisations on a one to one basis. The purpose of these meetings is to share detailed dialogue regarding one or more specific proposed workshops and to draw out the interviewees' qualitative and quantitative views relating to specific cost reduction opportunities.

— These interviews will provide a key source of confidential information that we will combine with other available information to form the basis of dialogue in the workshops.

— See Appendix C for the organisations that we engaged with.

Analysis:

— We reviewed the outputs of all meetings in order to achieve preliminary population of the supply chain cost reductions pathways matrix, in terms of both cost reduction forecasts and evidence to support those figures.

— We reviewed the output of all meetings to finalise the shape, content and invitees for the following workshops.

— The Focus Interviews helped to plan the structure and shape of the workshops, guiding the design in order to drive robustness into the supply chain matrix and to drive maximum benefit from the workshop discussions.

Output:

— Preliminary populations of the supply chain cost reductions pathways matrix

— Further testing of pathways and industry appetite for the pathways.

— A detailed plan of areas the challenge during the workshops.

Supply Chain Cost Reduction Pathways Model and Matrix Development

Objectives:

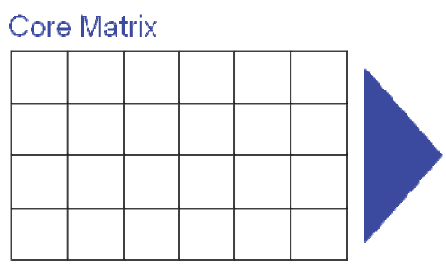
To capture from industry a comprehensive and robust matrix forecasting anticipated supply chain cost reductions across a number of levers and wind farm elements. To generate as much robustness as possible in the matrix and provide clarity on sources of data and interpretation/analysis to generate the final supply chain cost reduction forecast. To capture narrative evidence from industry to support and give credibility to the forecast cost reductions.

Key engagement:

- Work closely with the Focus Interviews and Work Shop Leads to robustly incorporate the outputs to the supply chain matrix
- Engage research activity where industry has not been able to give a clear and robust point of view, resulting in a critical gap in the matrix
- Work closely with the technology work stream to ensure supply chain inputs to the wider model are accurate, consistent and understood. Additionally, ensure that the supply chain work stream fully understands how the wider model operates and therefore is able to produce accurate inputs to the wider model
- Work with The Crown Estate to gather their guidance and coaching on the supply chain cost reduction pathways

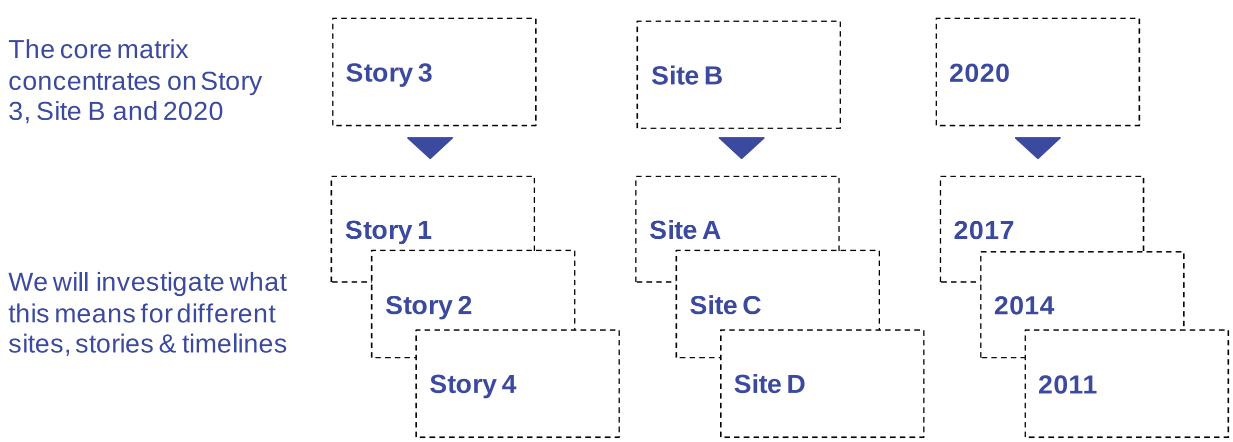
Analysis:

We followed a robust process to capture the quantum of all of the cost reduction pathway opportunities within the supply chain matrix. To achieve this we followed 4 key steps to populate the core supply chain matrix:

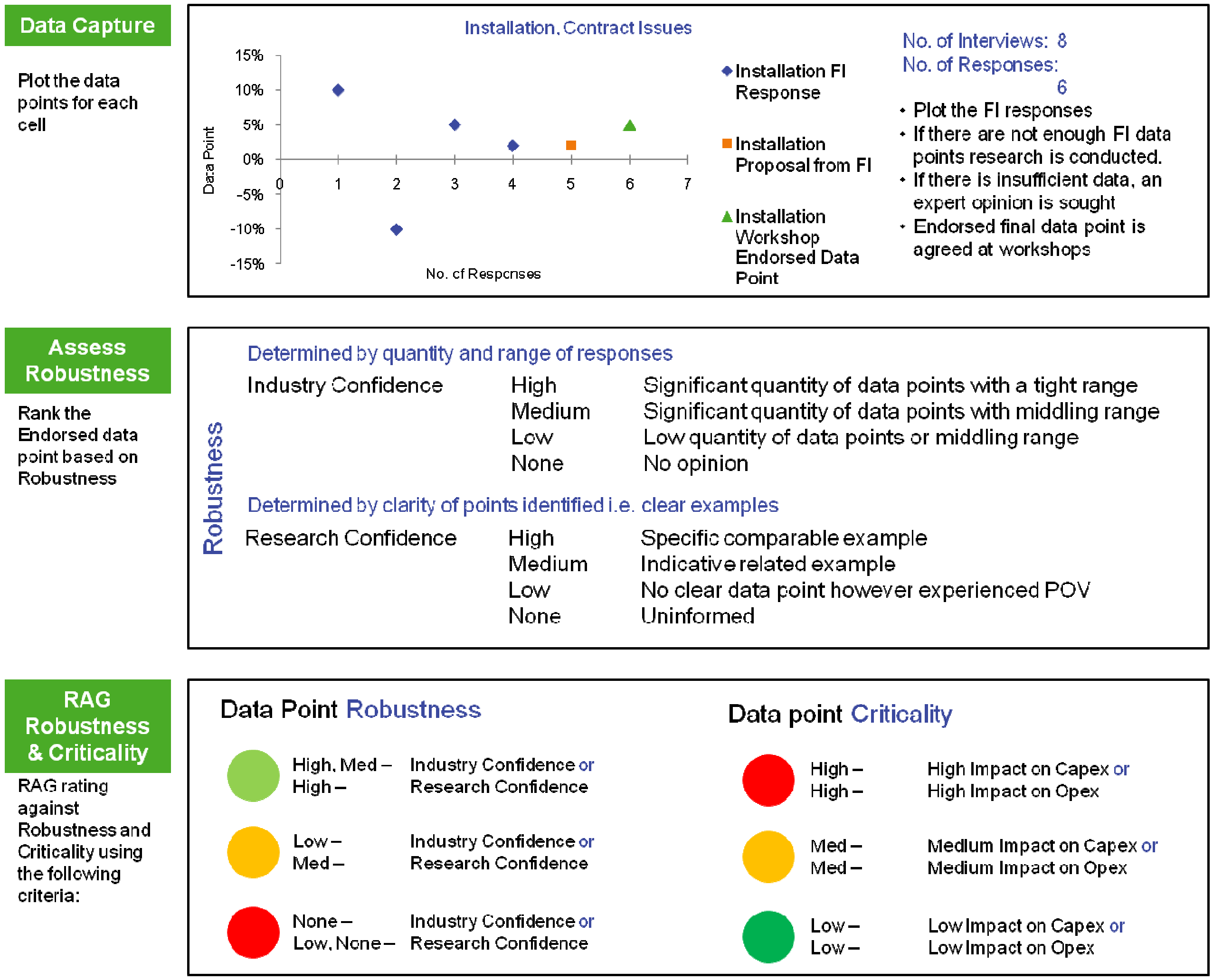


- Step 1 Capture FI outputs, gather expert opinion's where necessary & research data points – pull together and populate core matrix.
- Step 2 Rank data points according to robustness & criticality.
- Step 3 Identify adjustment factors for different sites, stories and different timelines.
- Step 4 Use workshops to validate data indentified and provide consolidated industry point of view.

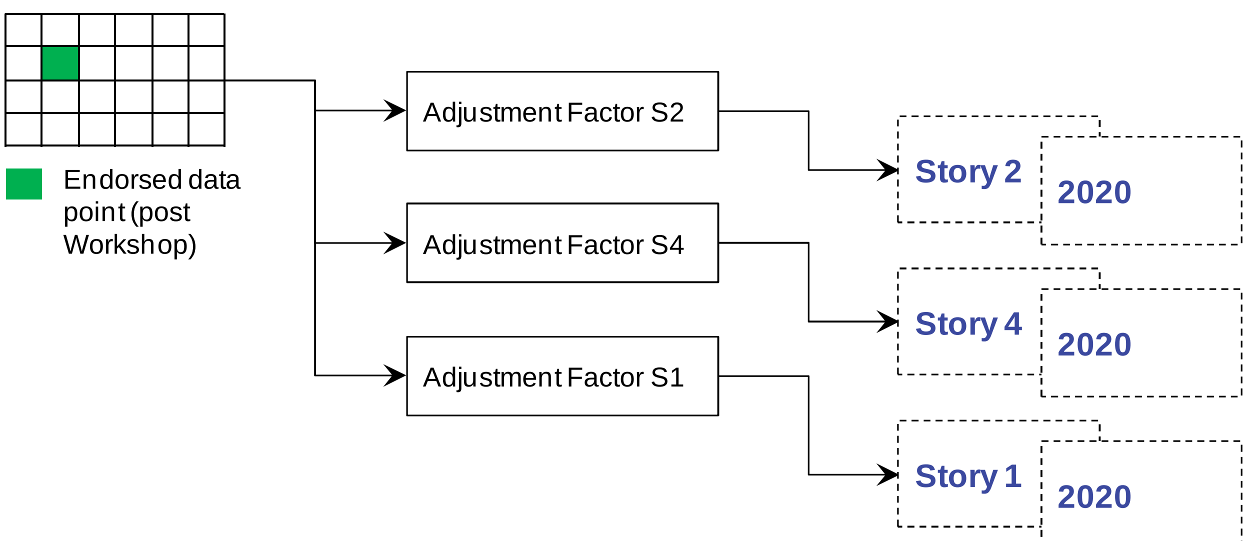
The core matrix was compiled for Story 3, Site B and Year 2020. We then investigated how this core matrix need to the adjusted for different sites, stories & timelines by deriving adjustment factors:



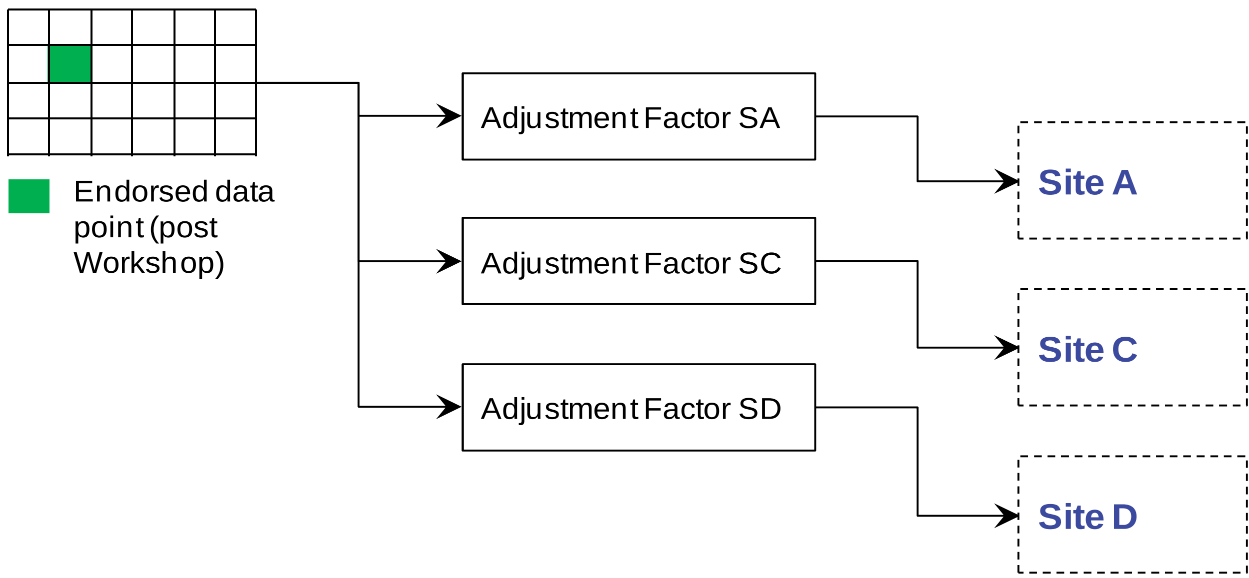
All data for cost reduction pathways and adjustment factors were derived from focus interviews, workshops or research. In populating the matrix we capture and validate data, determine its robustness, determine criticality and identify criticality gaps:



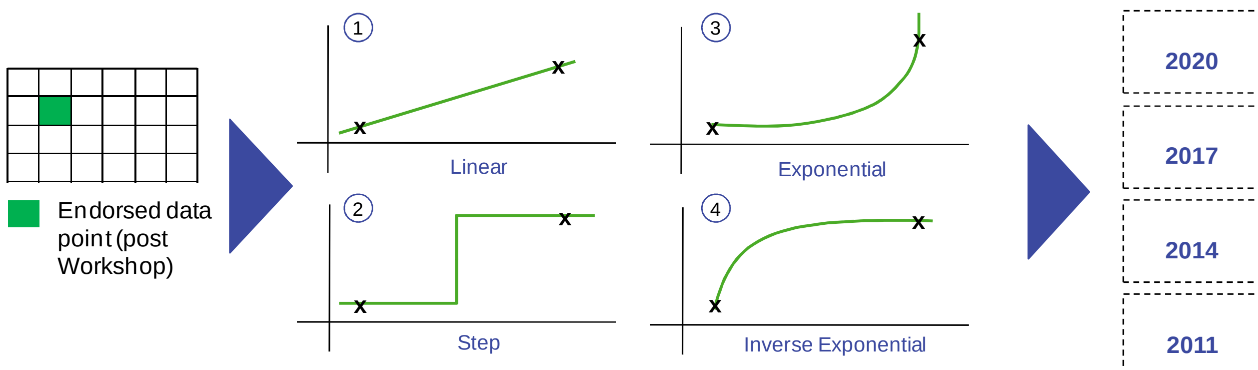
To translate core matrices into stories and sites, we used focus interviews, workshops and expert opinion to determine adjustment factors. We applied the same process as for the core matrix as to determine the appropriate adjustment factor and applied that to each cell of the core matrix to generate the equivalent matrix for each story and site:



Apply the adjustment factor for each story



To determine the affect at particular points in time we suggested 1 of 4 different profiles to interviewees in focus interview and workshops:



Although we suggested these time profiles, we also allowed respondents to select other time profiles, e.g. double step.

The delivery of cost reductions enabled by technology innovations to reduced price for the consumer through the supply chain was given specific treatment:

- An issue was identified around the potential retention of technology cost savings by the supply chain and the how that should account for that in the supply chain model. Specifically, the retention of the cost savings delivered through technology innovations as increased margin.
- This was accounted for by adjusting the competition lever in the supply chain model across the stories and timelines for supply markets where a lack of competition was anticipated, enables suppliers to retain cost improvements as margin
- We focused on the key supply markets of Wind Turbine, Wind Turbine Nacelle, Foundation & Installation (Towers was considered a mature market and therefore technology innovations cost savings were passed straight through the supply chain)
- We studied information on current suppliers and potential entrants to these key markets and synthesised this into a high level point of view on competition

- In view of the forecast technology savings and anticipated competition in the market place adjustment factors for the competition cost reduction lever were introduced to reduce its effect, turn it off, or reverse its effect, simulating either pass through of savings or retention of the cost savings as increased margin.

Example:

- Technology modelling predicts that technology innovations will produce a 20% reduction in the cost of a specific warm farm element
- Data is assembled on the current suppliers and likely entrants to the market
- High level analysis of the data suggests that the supply market will be monopolised by one key supplier
- The assumption becomes that that supplier will retain all of the technology cost savings
- For that scenario, the 10% competition saving in the core matrix becomes a -10% saving (i.e. 10% price increase) as the 20% technology saving is moved from base costs into supply chain margin.

Output:

- Core Supply Chain Matrix describing the quantum of cost reductions possible through the various pathways
- Evidence and narrative to support the numbers in the core matrix
- Adjustments factors to transform the core matrix for all stories, sites and time lines
- Evidence and narrative to support the adjustment factors
- High level analysis of the key supply markets to determine competitiveness
- Adjustment in the competition lever cost reduction to simulate pass through of base costs through technology innovations or retention in the supply chain as increased margin

Research

Objectives:

Where industry was not able to provide a clear and unambiguous point of view on a supply chain cost reduction pathway leading to a critical gap in the supply chain matrix, provide a data point to fill that gap through desk research

Analysis:

- Key gaps in the supply chain matrix are identified using the approach described above
- The list of critical gaps is used to develop a research brief
- Desktop research is conducted in accordance with the brief to source a suitable data points to fill critical gaps
- The confidence in each research point is articulated, to clarify how well the critical gap has been filled

Output:

- Evaluation of critical gaps identified in the supply chain matrix following engagement with industry
- Desk top research against each critical gap to identified a suitable alternative data point

Industry endorsement (Workshops)

Objectives:

To obtain industry endorsement from key industry players in a cross-work stream plenary meeting.

Key engagement:

— Cross-stream and industry-wide workshops were arranged to enable us to present findings and facilitate discussion and adjustment of results to achieve industry endorsement. These workshops also discussed messaging of the report and any potential next steps in order to retain momentum established, including relating to continuing to grow understanding of cost reduction, relevant drivers and vehicles for collaboration.

Analysis:

— Final analysis of cost reductions and pathways and preparation of proposed charts that summarise, in advance of industry dialogue.

— Preparation of material for final industry workshop.

Output:

— Industry endorsed versions of the draft pathways.

Reporting

Objectives:

Present the study transparently and robustly for use by the industry, public sector and other interested parties.

Key engagement:

— Clarification of specific points with industry suppliers.

— Feedback and guidance from The Crown Estate.

Analysis:

— Incorporation of all project data and knowledge

— Content rich point of view on the market place in terms of general conditions, key supply chain enablers and pre-requisites

— Support for the supply chain matrix in terms of justification and narrative around the final cost reduction pathways

Output:

— Work stream report and input to final overall report

— Support to communications team regarding messaging.

Appendix B: Oil and Gas Case Study

Introduction

Following the boom and bust of the 1970s and 1980s the Oil and Gas industry experienced relatively stable oil prices. During this period however, exploration and production costs continued to raise squeezing margins and diminishing internal rates of return. To stay profitable, oil and gas companies has to rethink their strategies and their relationship with the supply chain.

This Appendix provides an explanation of the initiatives that the O&G industry put in place through the 1990s in order to drive costs down:

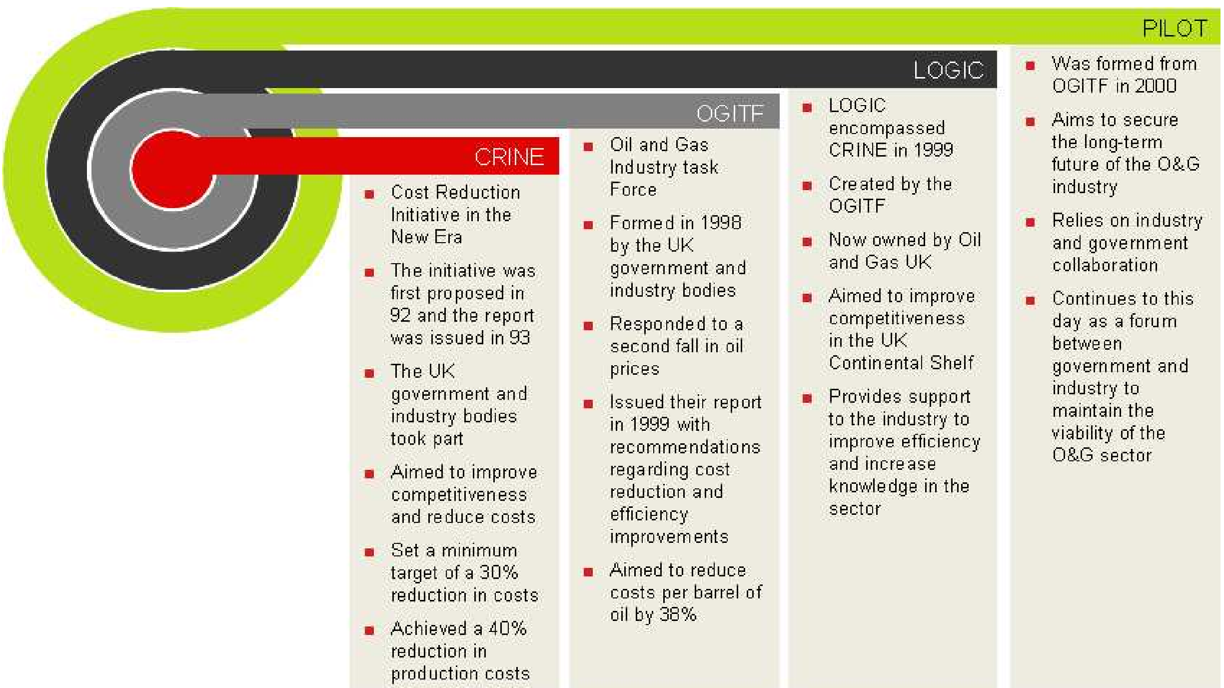
— CRINE – Cost Reduction Initiative of the New Era

— OGITF- Oil and Gas Industry Task Force

— LOGIC

— PILOT

Figure 30: Oil and Gas Initiatives



Of particular relevance to the offshore wind industry are the following:

Drive towards standardisation

Companies in the oil and gas sector typically used bespoke engineering solutions but vendors offered standard equipment packages and materials leading to modifications and bespoke solutions.

As a result of CRINE's recommendations, there was a general move towards using standardised equipment. This reduced equipment costs by up to **25%** ([69]) as it eliminated time spent by contractors working out the interfaces between component parts; it eliminated inefficient manufacturing and construction methods; improved economies of scale; reduced the need for complex and excessive documentation; and reduced the requirement for multiple audits and certification processes. Also, the move away from made-to-measure designs of offshore installations resulted in reduced maintenance costs.

Utilising standardised equipment also allowed repeatability of design and construction. This also simplified the process across the whole of the sector and provided fit-for-purpose equipment that led to increased safety levels, higher quality assurance and better quality control. By purchasing major equipment as standard products benefits were received in terms of volume discounts.

Rationalising and specifying components simplified the number of parts used across the industry and it also allowed personnel to became more familiar with the parts, apply their knowledge better and be more flexible.

Moving away from traditional lump sum adversarial contracting

A change in contracting forms and a shift towards collaborative working has resulted in up to **45%** cost reductions[70].

The industry has moved to a more appropriate allocation of risk to party best able to manage it, rather than pushing the cost of risk from the client to the contractor and down the supply chain. Contracts are less adversarial and onerous, focusing on collaboration and the earlier involvement in the project of necessary parties. Also, improved contracts have reduced the number of legal disputes.

Savings were also attributed to using industry standard contracts developed by CRINE focusing on general terms and conditions. These reduced the cost of legal fees and it also the time spent on signing the contracts, allowing projects to be initiated earlier and quicker.

Collaboration

A culture of mistrust had characterised the oil and gas industry. CRINE and the OGITF focused on the benefits to be gained through collaboration and cooperation resulting in savings of up to 20% as exemplified by the 8,500 tonne deck contract awarded to the contractor when only 19% of the detailed design was complete requiring close cooperation between parties in order to achieve completion within time and budget. This kind of collaboration would not previously been seen in the industry but it resulted in the project being delivered on before schedule for £5,500 per tonne, which was a 20% reduction on previous large deck contracts.

As well as vertical collaboration, the industry is now more keen to collaborate across peers. The tools offered by LOGIC have improved communication between the industry sharing resources, as seen through the Vantage POB scheme which tracks personnel and the Flight Share helicopter scheme.

Shorter summary documentation

Shorter summary documentation regarding component parts meant that the volumes that had previously been produced detailing specifications of parts had been reduced, often, and significantly, to just a single side.

CRINE Case Study

Introduction

CRINE was initiated in 1992 by the UK Offshore Operators Association (now Oil and Gas UK) within the context of low oil prices and rising costs; in the early 90s the cost of a barrel of oil fell from $35 to $12. Its main aim was to bring together all major oil and gas stakeholders such as the oil and gas companies, contractors, manufacturers, service companies and the UK Government (the then Department of Trade and Industry) to improve competitiveness and reduce the cost base of the UK's

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[69] The CRINE report, 'Cost Reduction Initiative for the New Era', 1993.

[70] The CRINE report, 'Cost Reduction Initiative for the New Era', 1993

continental shelf development and production activities. When launched, CRINE targeted a 30% reduction in capital costs of offshore platforms and a 50% reduction in operating costs over the following 20 years.

CRINE relied on a change in industry mind-set regarding working practices fostering alliances and partnerships to improve collaboration and encourage a culture which rewards individual and collective initiatives. Also, providing a more flexible approach in contractual obligations so that risk could be allocated to those best able to manage it and working towards a set of standardised functional specifications to both reduce costs, lead-time for delivery and facilitation of spares

The O&G sector before CRINE was characterised by adversarial relationships and mistrust at all interface levels. The costs associated with this were high. CRINE therefore advocated a culture which reflected teamwork and openness, with the whole industry working towards common objectives. The CRINE body acknowledged that senior personnel would only alter their work practices on seeing direct benefits from the CRINE initiatives.

CRINE initiatives were adopted by the majority of the industry and resulted in a 40% reduction in the cost of oil and gas field developments (Ref: Wood Mackenzie). Examples given below:

Table 40: Cost reduction delivered

Cost Reductions	How delivered
45%	Saved on drilling and completion costs by BP due to its incentive drilling contract
24%	Saved through improved well delivery by BP due to its incentive drilling contract
15%	Saved on Philipps' procurement budget thanks to its joint operator and contractor management team
15%	Projects savings reduction thanks to Conoco's alliance arrangements with contractors
7%	Saved on capital costs by BP's integrated management system

Key focus areas

CRINE focused on six areas each of which had separate recommendations:

Equipment Standardisation

CRINE recommended that oil and gas companies should maximise the use of standard equipment and materials, as well as the application of standard design and procedure; that companies should request vendor standard equipment packages and materials and that this practice should become commonplace.

Functional Specifications

CRINE recommended that the array of codes, standards and specifications prevalent in the oil and gas industry should be rationalised and simplified resulting in fit-for-purpose standards and certifications for use by the whole industry. This would eliminate specifications that had been too complex, too prescriptive or contain contradicting requirements.

The proposal was for the new standards to be adopted as national and international standards.

Using criticality to determine documentation requirements

It was proposed that documentation needs ought to be rationalised through the application of criticality assessments and determination of ultimate user needs and requirements and that documents should only be kept if they are required for a safety case. This will eliminate the retention of superfluous documents which do not affect operability.

Simplifying contract language and eliminating adversarial clauses

- Current contracts often vary in complexity and content from project to project.
- By setting common objectives between operator and contractor, and including non-adversarial clauses, results in projects completed in shorter times and at a lower cost.
- The inclusion of excess bonds, retention of funds, liquidated damages, extreme liability and indemnity clauses should be eliminated.

— Standardisation focused primarily on general terms and conditions.

Raising credibility of quality qualifications

- Successful development of oil fields is dependent on consistent high quality materials, design, manufacturing, engineering and construction.

- By improving the quality of products it will support the development of standardisation.

- A reliable system of quality assurance can also enhance safety.

- High levels of quality assurance will improve the credibility of the industry

- Government rationalisation of regulations

Role of the government

The CRINE report was in support of the trend for government to set goals rather than prescriptive legislation and proposals for streamlining the procedures for preparation and submission of Field Development Programmes (Annex Bs) were welcomed.

It was recommended that there should be further application of self-regulation and self-certification. This would make use of operators' internal documentation and would be monitored by internal management systems.

Of the six areas covered by CRINE, some were more influential than others:

Table 41: Six areas covered by CRINE

More influential	Less influential
• Standardisation resulted in regularly used component parts, requiring less training for personnel and a less highly skilled workforce. This resulted in a savings due to lower labour costs • Ensuring performance standards of components helped to maintain outputs on a rig • Maintaining a dedicated output is supported by strong quality assurance of components • When functional specifications are set it looks at the asset from the initial design stages to build, operation and demolition. By considering the life cycle of the asset improvements are made • Contract clauses have been beneficial in reducing the number of legal disputes • Government rationalisation of regulations	• Documentation needs. Companies should reduced the need for volumes of documents which detail their products. Instead a briefer summary document reduces the need for so much paper and reduces the time spent on interpreting the documents • Often a standard contract receives repeat modifications, thus no longer acting as a standard • It would be better for the industry to modify the standard contract and that this become the permanent norm, thereby reducing the need for repeated individual modifications.

OGTIF Case Study

Introduction

The Offshore Gas Industry task Force (OGITF) was created in 1998 as a response to another fall in oil prices and the maturing of the UK continental shelf. The task force's aim was to reduce costs per barrel from $13 to $8, a reduction of 38% against a backdrop of a barrel of oil selling for $20. A further aim was to increase the UK's share of the world's oil and gas supplies market and services by 50% in the following five years.

Membership of the task force included:

— John Battle, former Minister for Energy and Industry

— Lord MacDonald of Tradeston, Minister for Business and Industry at the Scottish Office

- Government departments such as the DTI, Treasury, DETR and the Scottish Office
- Representatives from industry including: oil companies, suppliers and unions.

Key areas of focus

The OGTIF created six working groups which reported back their findings and issued their report to government and industry in 1999, detailing short, medium and long-term objectives:

Competitiveness

- Develop supply chain
- Promote best practice
- Maximise collaboration
- World class benchmarking

Fiscal Measures

- Encourage investment in the industry
- Capital Gains Tax rollover relief
- Abolition of royalty and PRT measures targeted at additional investment

Regulation and Licensing

- Maintain a best-in-class regulatory environment
- Reform licence ownership structure
- Improve working relationships between licensees

Skills and Training

- Identify and forecast future skills needs
- Encourage an increased commitment to training
- Better utilisation of existing funds, labour pool online

Innovation & Technology

- Create an environment for enhanced collaboration
- Share risks and benefits
- Focus on technology clusters
- Integrate the supply chain
- Stimulate the supply sector

Environment & Sustainable Development

- Improve environmental performance
- Set practicable long-term goals
- Promote innovation rather than relying on compliance
- Apply scientific analysis to assess environmental risk and impact

The OGITF's report resulted in the formation of LOGIC – an industry-funded organisation that stimulates collaboration and improves competitiveness and PILOT - a joint programme between the government and industry which aims to secure the long-term future of the sector.

LOGIC

LOGIC was created in 1999 by the OGITF to improve competitiveness in the UKCS and it was modelled on the Industry Forum (IF) of the automotive industry. The IF had been supported by the DTI and was a way to improve the industry's performance through best practice transfer.

With initial funding from the DTI and the industry, LOGIC was the vehicle used for delivering workshops and seminars on supply chain management, in-company assessments, share fairs and collaboration on logistics. LOGIC also manages a number of cross-industry projects such as Vantage POB, the Master Deed, Industry Mutual Hold Harmless Deeds and Industry Standard Contracts (see below).

LOGIC provides direct supply chain management support to companies and trading partners to facilitate efficiency improvements leading to world class performance, it identifies leading practice and transfers learning within the industry.

It is currently a not-for-profit wholly-owned subsidiary of Oil and Gas UK.

LOGIC offers six important services:

- **Vantage POB: the** Vantage Personnel on board system was developed in 2003 by twelve UK oil and gas companies to provide a personnel-tracking system supporting UK 'best practice' in offshore personnel logistics. The project was pioneering in achieving cross-industry collaboration and funding, and delivering a large-scale internet enabled system. It is currently used by over 35 leading oil companies and the service tracks over a million personnel movements per year to and from over 420 locations.

- **Master Deed** was introduced in 2003 to streamline asset trading in the North Sea. It improves the transfer of UKCS offshore licence interests and other agreements relating to associated assets and infrastructure. Nearly 260 companies holding more than 99% of licence interests have signed up and it creates a mechanism which simplifies the complex and time-consuming procedures previously involved in the sale and purchase of offshore licence interests in the UKCS.

- **Industry Mutual Hold Harmless** IHMM establishes a contractual relationship between different companies working together, meaning that in the event of an accident or damage to property, each company will be responsible for its own, avoiding complex litigation procedures involving claims and counter claims. The IMHH Scheme avoids overlapping insurance of identical risk. Using the IMHH Scheme to manage and control risks will, in the long-term, facilitate increased industry collaboration.

- **UK Flight Share** is a flight sharing agreement and Aviation Mutual Hold Harmless. It works along similar lines to the Industry Mutual Hold Harmless but between operators, contractors and helicopter companies, enabling helicopter sharing. The Flight Share Initiative has been developed to permit the sharing of excess seat capacity on North Sea helicopter flights. It works by having interested parties sign up via Deeds of Adherence to two enabling documents

- **Industry Standard Contracts** are widely used across the contracting community when tendering for new work. Formerly CRINE contracts, they have been developed by the Standard Contracts Committee and are issued by LOGIC for use within the industry between clients and their contractors. In 2000, approximately 70% of the contracts let on the UKCS are estimated to have used the Standard Contracts as their model.

- **Oil and Gas Trust Scheme** The Oil and Gas Trust Scheme has been established initially to assist the Department for Business, Enterprise and Regulatory Reform, BERR, in its move issuing all North Sea consents and notices as digitally signed legally admissible digital documents. It is also a set of standards for issuing digital certificates in the UK oil industry that can be used across the oil companies and supply chain to assure the integrity and accuracy of digital transactions.

Industry standard contracts have made the most impact followed by Master Deed and Vantage POB. Although there have been noticeable benefits of using LOGIC's services the systems do not operate flawlessly. For example, often a whole flight route is chartered for a particular company and if another company wants to have an employee fly on the same helicopter negotiation has to be undertaken between the two parties. This is not in the spirit of the UK Flight Share scheme and yet this occurrence is common.

PILOT

PILOT was established on 1st January 2000 as a successor to OGITF. It is a joint programme involving the Government and the UK oil & gas Industry - operators, contractors, suppliers, trade unions and SMEs - aiming to secure the long-term future of the Industry in the UK. PILOT's vision

"The UK Oil and Gas Industry and Government working together in partnership to deliver quicker, smarter, sustainable energy solutions for the new century. A vital UK Continental Shelf is maintained as the UK is universally recognised as a world centre for global business."

To make this vision a practical reality, specific deliverables were defined. The strategy was for 10 years of Industry/Government co-operation aimed at achieving the following outcomes by 2010:

- 3 million barrels of oil equivalent per day production beyond 2010
- £3 billion per annum Industry investment
- Prolonged self-sufficiency in Oil & Gas
- Up to 100,000 more jobs (than there would otherwise have been)
- 50% increase in exports (by 2005)
- £1 billion per annum additional revenue for new business

Since these outcomes have not all been achieved PILOT continues to see out the vision and look ahead to the next 10 years to 2020. PILOT continues as a forum between government and industry to discuss the condition of the sector and to build alignment about the future direction it should take

Every year PILOT organises an event called PILOT Share Fair where it promotes the Supply Chain Code of Practice:

Table 42: PILOT Share Fair where it promotes the Supply Chain Code of Practice

PILOT Share Fair	Supply Chain Code of Practice
• PILOT Share Fair is an annual event where the major oil and gas industry players reveal their plans for the next 18 months for projects in the North Sea • The event provides a good opportunity to network with other companies active in the UK Continental Shelf, as well as finding out key points of contact, and taking part in one-to-one discussions with potential clients • The Supply Chain Code of Practice is also promoted at the PILOT Fair Share • The Supply Chain Code of Practice is a set of best practice guidelines which aims to help ensure an efficient supply chain and reduce waste • The key aims of the Supply Chain Code of Practice is to improve performance, eliminate unnecessary costs, add value and boost competitiveness.	The benefits of being part of the Supply Chain Code of Practice include: • Applying industry best practice and good business ethics drives positive behaviours throughout the industry • Improves efficiency through the use of LOGIC industry standard contracts and Information to Tender (ITT) documents • Easier access to suppler and purchaser information and contracts • Reduced pre-qualification leads to a more efficient tendering process • Issuing and receiving meaningful feedback ensures all companies improve their service and gain repeat business • Promotes an organised approach to tendering and a greater choice of suppliers • Payment of invoices within 30 days which promotes better business performance and working relationships.

Project Pathfinder builds on PILOT Share Fair:

- Project Pathfinder was implemented by DECC as a way to provide information to the Oil and Gas industry so that the industry can plan ahead

- The initiative involves looking at current oil and gas projects which are new developments and those that are to be decommissioned in the UK continental shelf
- Information provided includes the location, type of development, timing of the opportunities and contact details of key people
- This ensures increased visibility for the contracting community
- The industry has supported this DECC initiative.
- DECC aims for continued support and that Project Pathfinder becomes a valuable tool for the supply chain so as to win a greater number of contracts in the UK continental shelf.

Project Pathfinder is a valuable tool for companies to plan ahead so as to form their strategy and win new work.

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Appendix C: List of Companies Consulted

Company	Focus Interview	Workshop
A2Sea	✓	✓
AbleUK	✓	✓
Alstom		✓
Atkins		✓
Blade Dynamics		✓
Centrica	✓	✓
Cosalt Wind Energy		✓
David Brown Gears		✓
Dong	✓	
EDPR	✓	✓
Eneco		✓
E.on	✓	
Forewind		✓
Gravitas		✓
Harland and Wolff	✓	
Mitsubishi		✓
MPI Offshore		✓
MT Hojgaard		✓
Natural Power		✓
NSW GmbH		✓
Owec Tower		✓
PD Ports		✓
Peel Ports		✓
Petrofac		✓
Port of Blyth representing BPA	✓	✓
REpower		✓
Repsol		✓
Ricardo		✓
RWE		✓
Saipem		✓
Seaway Heavy Lifting	✓	✓
Siemens	✓	✓
Sinovel	✓	
Smartwind	✓	
SSE Renewables		✓
Statoil		✓

Company	Focus Interview	Workshop
Strabag	✓	✓
Subsea7		✓
Tata Steel		✓
Technip	✓	✓
Van Oord	✓	
Vattenfall	✓	✓
Vinci Construction		✓
Visser & Smit		✓
Weserwind		✓

Appendix D: List of Acronyms

AC	Alternating Current
AGES	Asset Growth and Economies Of Scale
BCIS	Building Cost Information Service
BOP	Balance Of Plant
CAGR	Compound Annual Growth Rate
Capex	Capital Expenditure
CfDs	Contract for Differences
CRINE	Cost Reduction In the New Era
DC	Direct Current
DECC	Department of Energy and Climate Change
ECI	Early Contractor Involvement
EIB	European Investment Bank
EMR	Energy Market Reform
EPC	Engineer, Procure, Construct
EU	European Union
EWEA	European Wind Energy Association
FEED	Front End Engineering Design studies
FID	Financial Investment Decision
FOAK	First Of A Kind
GW/GWh	Gigawatt (Hour)
GWEC	Global Wind Energy Council
IMCA	International Marine Contractors Organisation
IMHH	Industry Mutual Hold Harmless
IO	Integrated Operations
IP	Intellectual Property
JCT	Joint Contracts Tribunal
JV	Joint Venture
KPI	Key Performance Indicator
LCOE	Levelised Cost Of Energy
LD	Liquidated Damages
LTA	Long Term Service Agreement
MV	Medium Voltage
MW/MWh	Megawatt (Hour)
NEC	New Engineering Contract
O&G	Oil and Gas
O&M	Operations and Maintenance
OCI	Optimised Contractor Involvement
OEM	Original Equipment Manufacturer
OGITF	Oil And Gas Industry Task Force
Opex	Operational Expenditure
OPITO	Offshore Petroleum Industry Training Organisation
OWCRP	Offshore Wind Cost Reduction Pathway
p.a.	Per Annum
R&D	Research And Development

ROCs	Renewable Obligation Certificates
TCE	The Crown Estate
TSA	Turbine Supply Agreement
UK	United Kingdom
WACC	Weighted Average Cost Of Capital
WCD	Works Completion Date